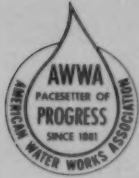


DECEMBER 1957



VOL. 49 • NO. 12

Journal

AMERICAN
WATER WORKS
ASSOCIATION

In this issue:

CONTROL OF TASTE AND ODOR

Sigworth

WATER PURIFICATION IN CANADA

Matheson, Forde

ANALYSIS OF 1955 OPERATING DATA

Seidel, Baumann

USPHS TREATMENT FACILITIES SURVEY

Porges

EVALUATION OF POLYPHOSPHATES

Larson

REVENUE-PRODUCING WATER

Committee Report

LIMITATIONS ON CONSTRUCTION FINANCING

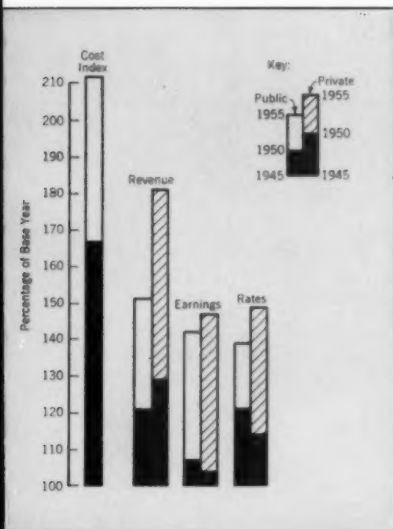
LeFever

CONFERENCE AND SECTION PROGRAMS

1957 Meetings

JOURNAL AWWA SUBJECTS AND AUTHORS

1957 Indexes

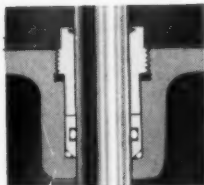
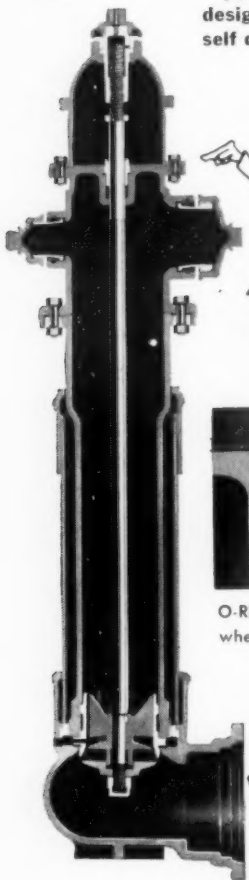


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Journal

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December 1957

Vol. 49 • No. 12

Contents

Control of Odor and Taste in Water Supplies.....	E. A. SIGWORTH	1507
Progress Toward AWWA Certification Program.....		1521
Survey of Water Purification Practice in Canada DELOSS H. MATHESON & A. V. FORDE		1522
Acceptability of Membrane Filter Procedure.....		1530
A Statistical Analysis of Water Works Data for 1955 HARRIS F. SEIDEL & E. ROBERT BAUMANN		1531
Summary of 1955 USPHS Survey of Treatment Facilities in Communities of 25,000 and Over.....	RALPH PORGES	1567
Correction—1955 Operating Data Survey.....		1580
Evaluation of the Use of Polyphosphates in the Water Industry THURSTON E. LARSON		1581
Revenue-producing Versus Unaccounted-for Water.....	COMMITTEE REPORT	1587
Factors Limiting Financing of New Water Works Construction ALFRED LEFEBER		1593
1957 Conference—Atlantic City.....		1595
Papers Scheduled at 1957 Section Meetings.....		1605
Reprints Available.....		1616
Index for Volume 49, 1957		
Subject Index		1619
Author Index		1631
Binding the Year's Journals.....		1638

Departments

Officers and Directors.....	2 P&R	Condensation Index	66 P&R
Coming Meetings	8 P&R	New Members	94 P&R
Percolation and Runoff.....	41 P&R	Section Meetings.....	102 P&R
Correspondence	56 P&R	Employment Information	104 P&R

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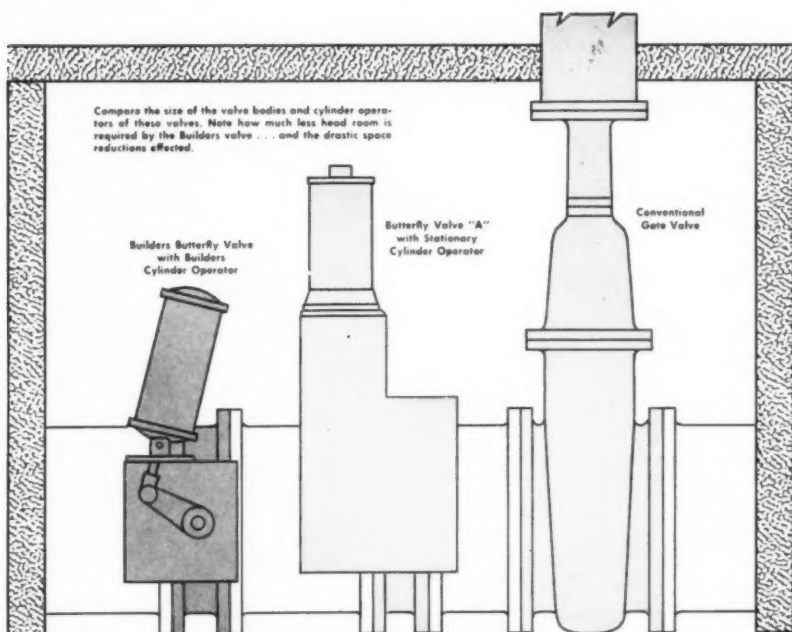
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LIST OF ADVERTISERS

	P&R PAGE		P&R PAGE
Alabama Pipe Co.	—	Hydraulic Development Corp.	14
Allis-Chalmers	81	Industrial Chemical Sales Div., West	—
American Agricultural Chemical Co.	100	Virginia Pulp & Paper Co.	39
American Brass Co., The	111	Inertol Co., Inc.	—
American Cast Iron Pipe Co.	21	Infilco Inc.	43
American Concrete Pressure Pipe Assn.	115	International Salt Co., Inc.	30
American Cyanamid Co., Heavy Chemi- cals Dept.	52, 53	Iowa Valve Co.	9, 95
American Pipe & Construction Co.	79	Johns-Manville Corp.	6, 7, 55
American Sanitary Mfg. Co.	—	Jones, John Wiley, Co.	104
American Well Works	34	Keasbey & Mattison Co.	26
Anthracite Equipment Corp.	—	Kennedy Valve Mfg. Co., The	—
Armco Drainage & Metal Products, Inc.	99	Klett Mfg. Co.	94
Badger Meter Mfg. Co.	68, 69	Koppers Co., Inc.	65
Barrett Div.	—	LaMotte Chemical Products Co.	96
Bethlehem Steel Co.	17	Layne & Bowler, Inc.	32
B-I-F Industries, Inc.	5, 45, 77	Layne & Bowler Pump Co.	73
Buffalo Meter Co.	29	Leadite Co., The	Cover 4
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)	5	Leo R. Leary	—
Burgess-Manning Co., Penn Instruments Div.	71	Leopold, F. B., Co.	15
Calgon Co.	89	Lock Joint Pipe Co.	3
Carborundum Co., The	49	Ludlow Valve Mfg. Co.	22
Carus Chemical Co.	98	M & H Valve & Fittings Co.	51
Cast Iron Pipe Research Assn., The	106, 107	Meter Specialty Co.	50
Celanese Corp. of America	10, 11	Milton Roy Co.	113
Centriline Corp.	—	Mueller Co.	13, facing p. 100
Chain Belt Co.	—	National Water Main Cleaning Co.	57
Chapman Valve Mfg. Co.	103	Neptune Meter Co.	40
Chicago Bridge & Iron Co.	—	Northern Gravel Co.	92
Clow, James B., & Sons	9, 95	Omega Machine Co. (Div., B-I-F Indus- tries, Inc.)	77
Cochrane Corp.	—	Orangeburg Mfg. Co.	—
Cole, R. D., Mfg. Co.	54	Permutit Co.	86, 87
Crane Co.	—	Philadelphia Quartz Co.	102
Darley, W. S., & Co.	50	Pittsburgh-Des Moines Steel Co.	97
Darling Valve & Mfg. Co.	27	Pittsburgh Equitable Meter Div. (Rock- well Mfg. Co.)	116
De Laval Steam Turbine Co.	93	Pollard, Jos. G., Co., Inc.	91
DeZurik Corp.	19	Portland Cement Assn.	—
Dicalite Div.	20	Pratt, Henry, Co.	37
Dorr-Oliver Inc.	Cover 3	Proportioners, Inc. (Div., B-I-F Indus- tries, Inc.)	45
Dresser Mfg. Div.	24	Reed Mfg. Co.	—
Eddy Valve Co.	9, 95	Reilly Tar & Chemical Corp.	—
Electro Rust-Proofing Corp.	75	Rensselaer Valve Co.	22
Electrovert Ltd.	—	Roberts Filter Mfg. Co.	—
Ellis & Ford Mfg. Co.	98	Rockwell Mfg. Co.	116
Etablissements Degremont	67	Rockwell, W. S., Co.	85
Filtration Equipment	—	Ross Valve Mfg. Co.	—
Flexible Inc.	—	Servicised Products Corp.	28
Ford Meter Box Co., The	36	Simplex Valve & Meter Co.	—
Foster Engineering Co.	56	Smith, A. P., Mfg. Co., The	31
Foxboro Co.	—	Smith, S. Morgan, Co.	—
General Chemical Div., Allied Chemical & Dye Corp.	58	Sparling Meter Co.	12
General Filter Co.	25	Steel Plate Fabricators Assn.	101
Glenfield & Kennedy, Ltd.	—	Tennessee Corp.	96
Golden-Anderson Valve Specialty Co.	48	Trinity Valley Iron & Steel Co.	18
Graver Tank & Mfg. Co.	23	U.S. Pipe & Foundry Co.	—
Graver Water Conditioning Co.	47	Walker Process Equipment, Inc.	—
Greenberg's, M., Sons	—	Wallace & Tiernan Inc.	38
Hammond Iron Works	35	Well Machinery & Supply Co.	83
Hays Mfg. Co.	33	Wheeler, C. H., Mfg. Co.	—
Hersey Mfg. Co.	16	Wood, R. D., Co.	Cover 2
Hungerford & Terry, Inc.	108	Woodward Iron Co.	109
		Worthington Corp.	—
		Worthington-Gamon Meter Div.	105

Directory of Professional Services—pp. 59-64 P&R



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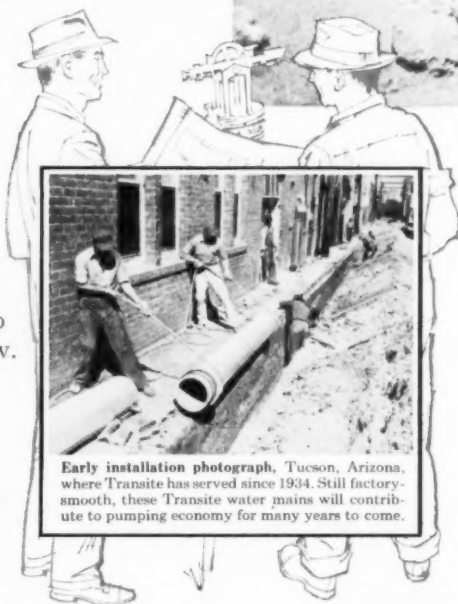
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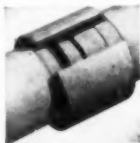
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Feb. 5-7—Indiana Section, at Sheraton-Lincoln Hotel, Indianapolis. Secretary, C. H. Canham, 3517 Manor Court, Indianapolis.

Feb. 13—New Jersey Section Winter Luncheon Meeting, at Essex House, Newark. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Mar. 12-14—Kansas Section, at Lamer Hotel, Salina. Secretary, Harry W. Badley, Representative, Neptune Meter Co., 119 W. Cloud, Salina.

Mar. 20-22—Montana Section, at Florence Hotel, Missoula. Secretary, Arthur W. Clarkson, Asst. Director, Div. of Environmental Sanitation, State Board of Health, Helena.

Mar. 23-25—Southeastern Section, at Dinkler-Plaza Hotel, Atlanta, Ga.

Secretary, N. M. deJarnette, Engr., Div. of Water Pollution Control, State Dept. of Health, 309 State Office Bldg., Atlanta, Ga.

Mar. 26-28—New York Section, at Van Curler Hotel, Schenectady. Secretary, Kimball Blanchard, Ludlow Valve Mfg. Co., Inc., 11 W. 42nd St., New York 36.

Mar. 26-28—Illinois Section, at La Salle Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 3440 Prudential Plaza, Chicago.

Apr. 16-18—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, John E. Olsson, Cons. Engr., 408 Sharp Bldg., Lincoln.

May 15-17—Pacific Northwest Section, at Davenport Hotel, Spokane, Wash. Secretary, Fred D. Jones, Asst. Supt., Water Dept., 306 City Hall, Spokane, Wash.

May 15-17—Arizona Section, at El Conquistador Hotel, Tucson. Secretary, Stanford I. Roth, Supervisor of Water Collections, Div. of Water & Sewers, Phoenix.

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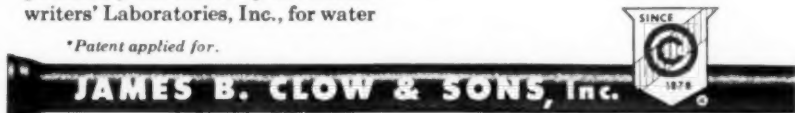
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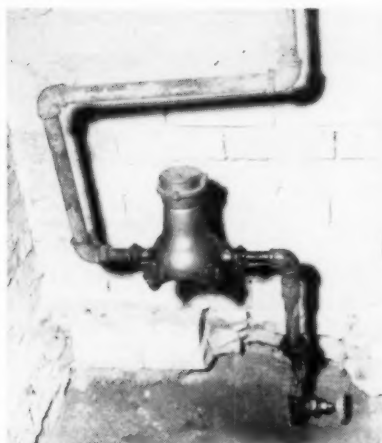
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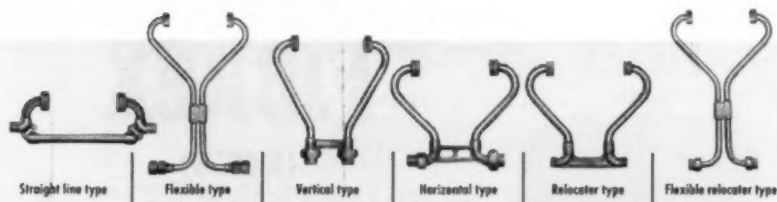


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For over 40 years HYDRO-TITE has been faithfully serving water works men everywhere. Self-caulking, self-sealing, easy-to-use. Costs about 1/5 as much as lead joints. Packed in 100 lb. moisture-proof bags.

HYDRO-TITE

(LITTLEPIGS)

**HYDRO-TITE**

(LITTLEPIGS)

The same dependable compound in solid form—packed in 50 lb. cartons—2 liters of pigs to the box—24 easy-to-handle Littlepigs. Easier to ship, handle and store.

FIBREX

(REELS)

**FIBREX**

(REELS)

The sanitary, bacteria-free joint packing. Easier to use than jute and costs about half as much. Insures sterile mains and tight joints.

HYDRO-TITE **HYDRAULIC DEVELOPMENT CORPORATION**

Main Sales Office: 55 Church Street, New York

General Offices and Branch: W. Medford Station, Boston, Mass.



Aerial view of the R. C. Harris Plant of The Municipality of Metropolitan Toronto; R. L. Clark—Commissioner of Works. Photograph was taken during construction of plant's additional facilities.

New plant extension for Toronto, Canada used Leopold Butterfly Valves

When the R. C. Harris Plant of The Municipality of Metropolitan Toronto, Canada, was constructed in 1939 with an initial capacity of 100 million Imperial gallons per day, provision was made for future extension to twice that capacity.

With the recent completion of this extension, which has been under construction since 1955, 200 million gallons per day are now available to meet the expanding needs of the fast-growing Metropolitan Toronto area. For this modern plant addition, Leopold class 50-16 rubber seat, tight shut-off 30" hydraulically operated butterfly valves were selected for use on the twenty filter wash water lines.



Workmen shown installing one of the Leopold 30" Butterfly Valves at the R. C. Harris Plant.

More and more water treatment plants are specifying Leopold equipment for dependable performance, long life, and economy. If you're planning on new plant construction or modernization of your present facilities, it will pay you to consider the advantages of Leopold products. Write for complete information, without obligation.

Leopold

F. B. LEOPOLD CO., INC.

ZELIENOPLE, PA.

COMPLETE WATER PURIFICATION AND FILTER PLANT EQUIPMENT • BUTTERFLY VALVES
FILTER OPERATING TABLES • MIXING EQUIPMENT • DRY CHEMICAL FEEDERS
GLAZED TILE FILTER BOTTOMS • FIBERGLAS-REINFORCED PLASTIC WASH TROUGHS

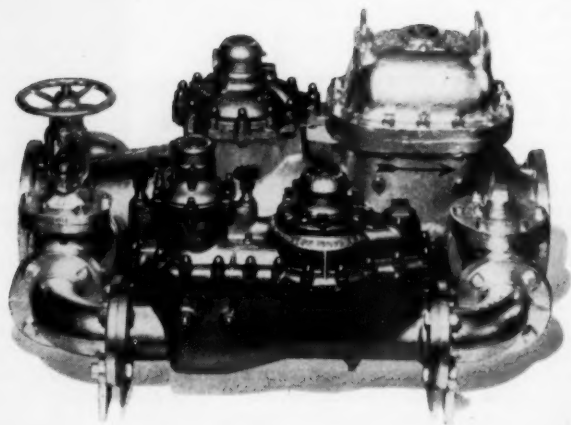
HERSEY

The HERSEY DETECTOR (Fire Service) METER equipped with a bronze case Compound Meter on its by-pass, meets the demand for accurately measuring all rates of flow from small domestic services through ranges required for industrial purposes and for fire service lines, without obstruction to the flow. This combination successfully meets the requirements of a large number of water works furnishing water through a master meter to consumers not under their immediate jurisdiction.

Listed as standard under the re-examination service of Underwriters' Laboratories, Inc. and approved by Factory Mutual Laboratories for use in Factory Mutual insured properties; also listed by Underwriters' Laboratories of Canada.

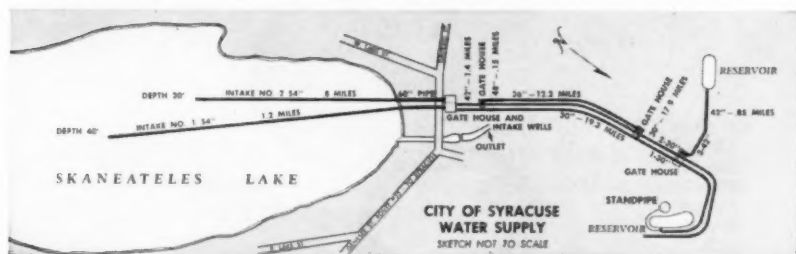
HERSEY MANUFACTURING COMPANY DEDHAM, MASS.

BRANCH OFFICES: NEW YORK — PORTLAND, ORE. — PHILADELPHIA — ATLANTA
DALLAS — CHICAGO — SAN FRANCISCO — LOS ANGELES





Underwater intakes laid in '93 and '38 are in "excellent condition" today



Sketch of Syracuse's water supply system. The lake source is about 20 miles from the city. Bethlehem has supplied thousands of feet of far-enamelled steel pipe used throughout the system.

This photograph was taken in 1938, when the City of Syracuse was installing its No. 1 water intake in Skaneateles Lake. Like No. 1, the newer intake consists of 54 in. ID x 3/8 in. steel pipe joined into sections on shore, floated to position, lowered to the lake bottom, and connected by divers. Intake No. 1 measures 6419 ft; No. 2 is 4213 ft long.

The 1938 intake pipe was supplied by Bethlehem in 30-ft lengths. It was coated and lined in our pipe shop with modern spun coal-tar enamel, a big improvement over the asphalt coatings used on the older line which was installed back in 1893.

Here's what the City's Division of Water reports: "Inspections of the exterior of the intakes by divers indicate that both are in excellent condition today."

Similar reports from all parts of the country make it clear beyond doubt that tar-enameled steel pipe, properly installed, will give excellent service and long life under the very toughest conditions.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

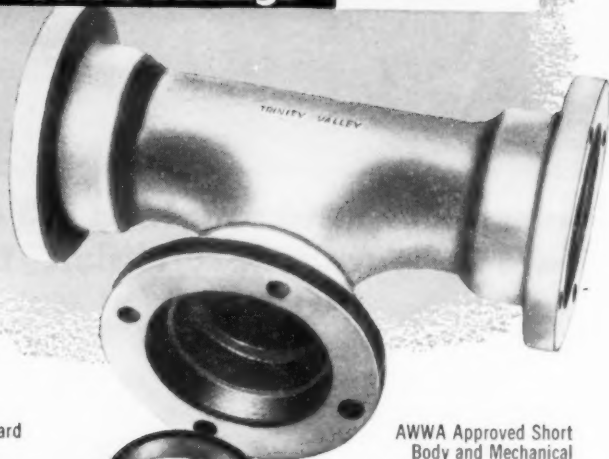
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL



TRINITY VALLEY

**For All
Cast Iron
Water Works Fittings**



AWWA Standard
Bell Spigot
Watermain
Fittings—2
through 36
inch.
Ring Tite
Fittings
3" thru
12"

Class
100 and
150

AWWA Approved Short
Body and Mechanical
Joint Watermain Fittings—
2 through 12 inch.

Fluid-Tite
Fittings
3" thru
12"



**TRINITY VALLEY IRON
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Phone PE 8-1925

Fort Worth, Texas

P. O. Box 664

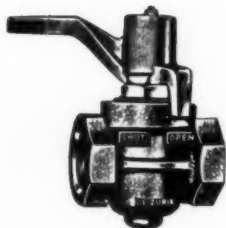
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TIGHT SHUT-OFF
in spite of grit...
Seats That Never
Need Replacing..**

When You Install DeZurik Plug Valves!

Their resilient-faced plugs close dead tight, in spite of grit, against a nickel seat that eliminates seat scoring and corrosion. 20% nickel alloy bushings eliminate stem seizures and assure easy operation.

In addition, DeZurik Plug Valves have *exclusive Eccentric Action* . . . eliminating the need for constant lubrication, and permitting the valves to be used on throttling services without the danger of contamination from lubricants . . . and without "chatter!"

DeZurik Valves are available in sizes 1/2" through 20", with manual and a full range of remote operators . . . at a cost much lower than you'd expect. Representatives in all principal cities, or for more information, write to



**DeZURIK
CORPORATION**
SARTELL, MINNESOTA

DIATOMITE FILTRATION

*solves site difficulties
for Montrose
Improvement District*

When the Montrose Improvement District in Westchester County, New York, decided to install a filtration plant to handle Catskill Aqueduct water (turbidity exceeding 10 ppm more than 50% of the time) they were faced with serious difficulties in respect to plant location. Available space was severely restricted, and the matter was further

complicated by foundation and ground water problems.

Diatomite filtration solved all the site difficulties, and allowed the filters and all mechanical equipment to be housed in one small two-story building which still provides adequate space for the addition of filters and pumps to double the present capacity if and when required. The present 2 Waterite vacuum filters, each with 500 ft.² of filter area, give the plant a filtration capacity of 2,000,000 gpd, yet occupy only 200 ft.² of floor space. Semi-automatic plant operation reduces supervision requirements and contributes to the ease and efficiency of operation which characterize this modern installation.



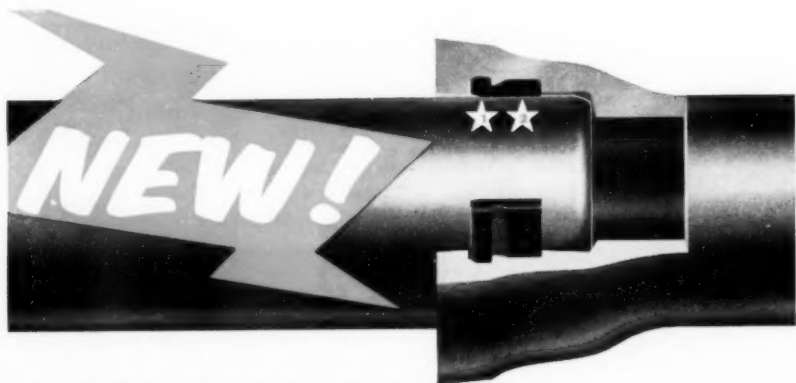
For more complete information on this plant and on the many advantages of diatomite filtration of municipal water supply, write to

*Adding Dicalite Filteraid at the
stilling well of a filter during the
precoat operation.*

Dependable **Dicalite**[®]
GLC
GREAT LAKES
DIATOMACEOUS MATERIALS

DICALITE DEPARTMENT

Great Lakes Carbon Corporation • 612 So. Flower St., Los Angeles 17, California



AMERICAN *Fastite* ★★ JOINT*

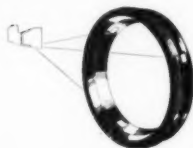
Another important AMERICAN development
★★ a superior double-sealing single gasket type joint

Now... from the American Cast Iron Pipe Company, a scientifically designed, *field-tested* single gasket type joint that helps keep installation time and labor costs at new lows! Introduced only after intensive research and testing, and after numerous successful field installations, American Fastite Joint* cast iron pipe offers new simplicity and speed in installation, plus the superior features of its *double-sealing*★★ dual-density rubber gasket.

Write today for a descriptive brochure, or call your nearby American Cast Iron Pipe Company representative for full details on this new superior *double-sealing*★★ joint... American Fastite.



American Fastite Joint 6" pipe installed in Kansas for water service. This installation demonstrates the wide deflection capability of the American Fastite Joint*



NEW! FOR ELECTRICAL THAWING

A special American Fastite Joint* gasket with moulded-in copper strips for contact between the socket and the pipe end.

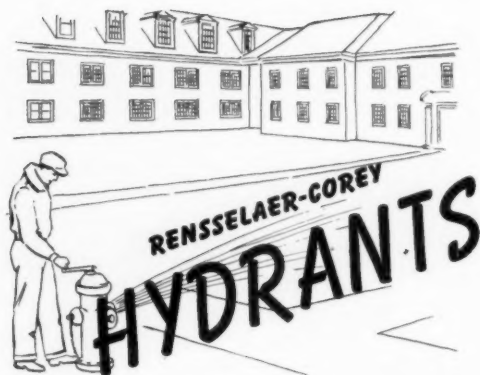
*Underwriters Laboratories, Inc. Approved

*patent applied for

A AMERICAN
CAST IRON PIPE CO.
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SALES OFFICES

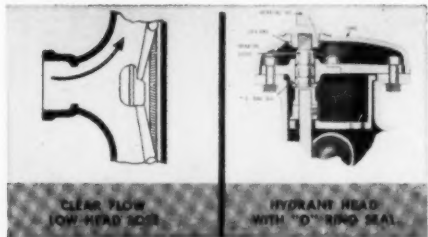
New York City • Chicago
Kansas City • Minneapolis
Dallas • Denver • Orlando
Los Angeles • Pittsburgh
San Francisco • Cleveland



This is the hydrant that has been the standard of excellence in hundreds of cities for many years. Inspectors, maintenance men and fire chiefs, all have their reasons for endorsing the Rensselaer Corey Hydrant.

The illustrations show the clear-flow design which insures low head loss and maximum flow. Maintenance men like the simplicity of design and the speed of removing, inspecting and replacing the working parts as a single unit.

This hydrant opens with the pressure, is easy to operate and cannot stick. No digging for repairs, or for standpipe breakage. Now available with any type connection and "O" Ring seal.



Ask for
Bulletin "G"

LUDLOW & Rensselaer

LUDLOW

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VALVES & HYDRANTS

Since 1861 THE LUDLOW VALVE MANUFACTURING CO. Troy, N. Y.

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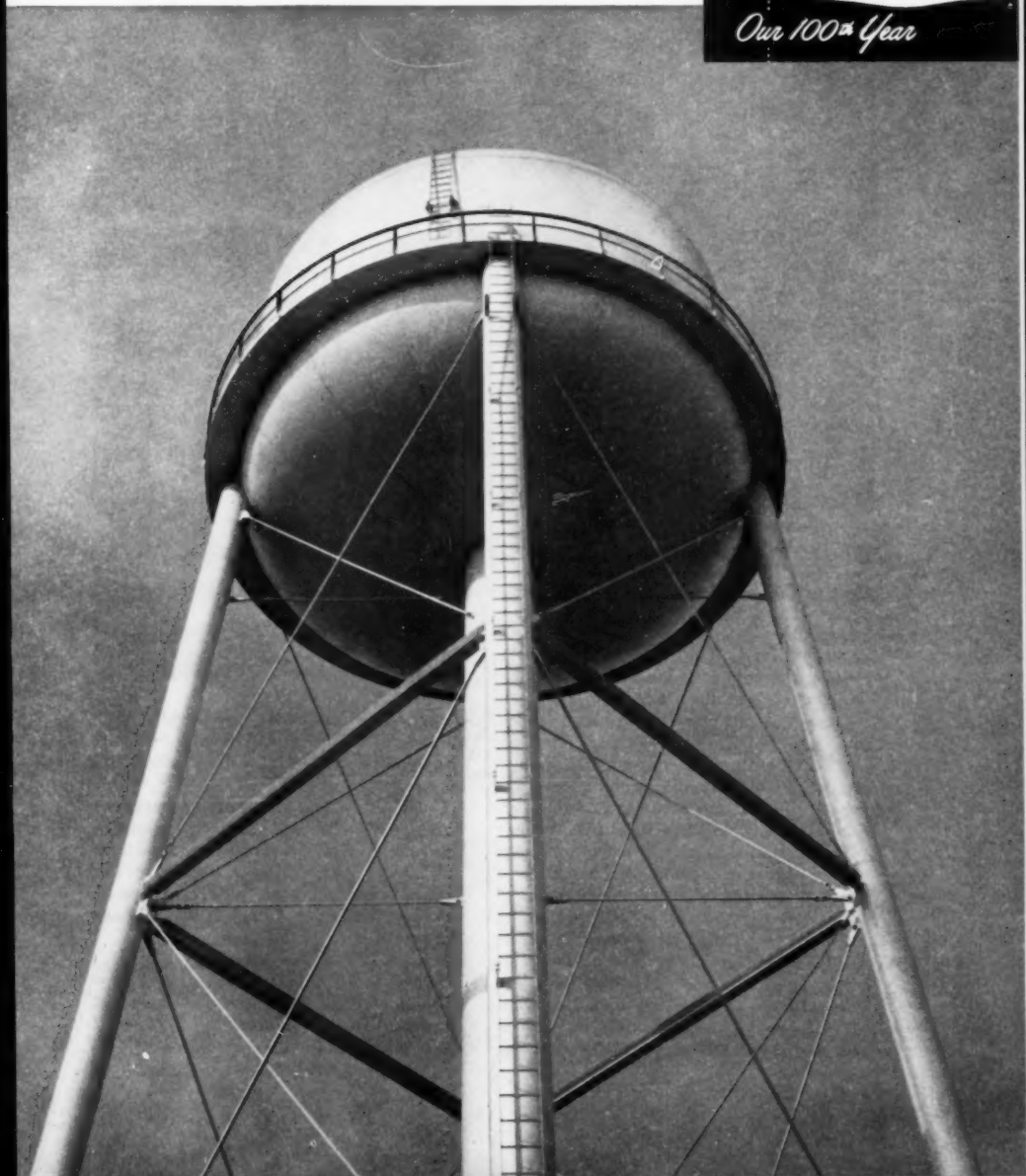
Nationwide manufacturing facilities, backed by 100 years of skilled fabricating experience in steels and alloys, enable Graver to build the water storage tanks for every requirement. Designed, fabricated and erected to the highest welding standard, Graver tanks of every type are built to meet individual needs. Let Graver help in solving your water storage problems. **GRAVER TANK & MFG. CO., INC.**

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Our 100th Year





DELIVERING WATER CHEAPER

This 48,980-foot water supply line at Spartanburg, S. C., was installed in 50-foot steel pipe lengths. Ease in making up the Dresser joints was the factor in speeding up installation of the line, thereby causing a minimum of inconvenience to property owners.

Pipe Line With Built-in Public Relations

Dresser Couplings build good will with speed, convenience, flexibility, long life

Water pipe installations have a thousand superintendents. They are the public — people whose homes, businesses, or daily routines are affected by the project.

Many watermen have found that use of steel pipe and Dresser Couplings offers an excellent way to build and maintain public good will. This versatile combination helps remove the principal sources of public irritation because of these important results:

Speed. Easy-to-install Dresser Couplings require only two man-minutes per bolt, or less; allow joints to be completed in record time.

Convenience. Most waterworks operators backfill a Dresser-coupled line on the heels of the laying crew. Streets, driveways and sidewalks are tied up for a shorter time.

Flexibility. Dresser Couplings compensate for slight misalignments, permit by-

passing obstructions. You can make curves with straight pipe—get up to 4° deflection at each joint of a new main or main extension.

Long life. Leakproof joints eliminate annoyance of redigging for repairs. Specially compounded rubber gaskets protect lines for life.

Good will is just one great advantage of using steel pipe and Dresser Couplings. The job is also done more economically.

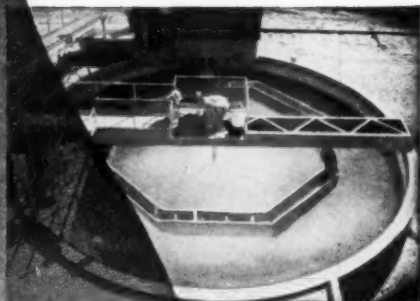
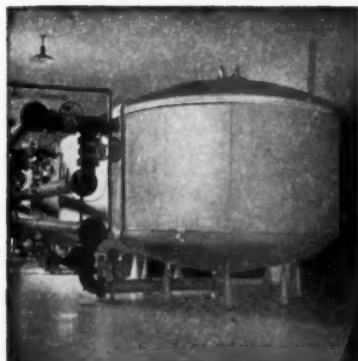
Wherever water flows, steel pipes it best. Always put steel pipe and Dresser Couplings in your specifications. Dresser Manufacturing Division, Bradford, Pa. Sales offices in: New York, Philadelphia, Chicago, S. San Francisco, Houston, Denver, Toronto and Calgary.



Why

General Filter?

There are many reasons why municipalities and industries have installed General Filter water treating plants:



ENGINEERING KNOW-HOW . . . General Filter's design and construction engineers are familiar with the problems involved in water treatment.

INSTALLATION SUPERVISION . . . General Filter "job-engineers" each installation to the consulting engineer's specification . . . supervises the installation and trains the personnel who will work with the equipment.

OPERATIONAL DEPENDABILITY . . . for twenty years General Filter has concentrated all of its efforts toward "better water treatment". Their efforts have produced water treating plants and equipment that are completely dependable.

GREATER ECONOMY . . . the only real test of economy is a long-term test. General Filter plants stand up over the years providing "better water" with minimum maintenance, longer trouble-free, smoother operation.

Find out why you should specify General Filter . . . Write today for detailed information regarding your water treatment problems.

General Filter Company

AMES, IOWA

. . . better water

AERATORS • FILTERS • TASTE AND ODOR • ALKALINITY CONTROL • HIGH CAPACITY
RESINOUS ZEROLITE • IRON RUST REMOVAL • DEMINERALIZATION • SOFTENERS



It takes just two steps to assemble the FLUID-TITE Coupling. Lubricate the tapered edge of the gasket. Then slide in the pipe.

Major Advance In Waterworks Industry. K&M's exclusive FLUID-TITE Coupling provides permanent, water-tight, root-tight connections.

SLIDE IT IN QUICK... IN 2 EASY STEPS

IT'S "K&M" ASBESTOS-CEMENT PRESSURE PIPE WITH EASY-TO-INSTALL FLUID-TITE COUPLING

Installation is fast and economical! It doesn't require skilled labor, heavy machinery, or heavyweight coupling pullers. Install it in any weather.

The seal grows tighter as the pressure climbs! Coupling rings expand as water mains fill. Rings have holes on one side for self-energizing action.

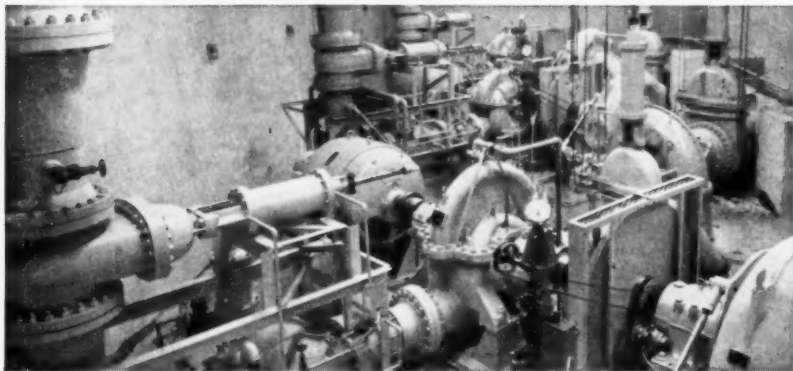
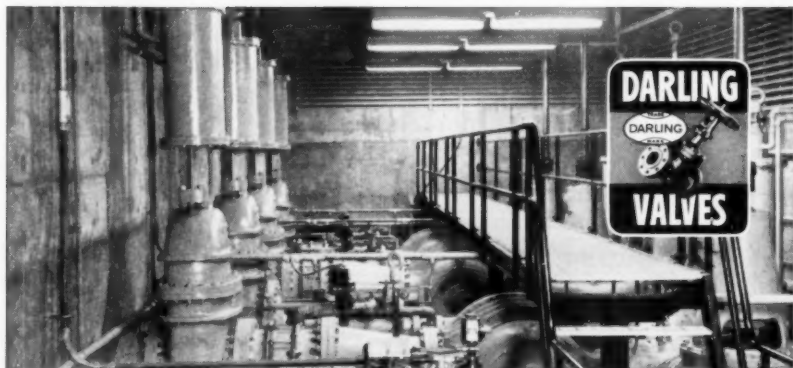
It's practically indestructible! "K&M" Asbestos-Cement Pressure Pipe is non-tuberculating, non-electrolytic,

and corrosion-resistant. Its first cost is often the last cost. Pressure remains normal—pumping costs stay low.

Write today for more information.



KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA



DARLING VALVES . . . where top performance is a keynote

MODERN planning and the latest in equipment facilities comprise a high efficiency team at the Washington Suburban Sanitary Commission's new Anacostia Sewage Pumping Station.

Note that the large Darling gate valves are cylinder operated and installed in both horizontal and vertical lines. These valves, with their fully revolving double disc parallel seat

design, are particularly suited for such service. Not only are the seat faces automatically wiped clean during each operation, but the principle also assures uniform wear distribution, extended life and consistently tight closure.

Darling gate valves are available in a wide range of sizes and types for all normal and unusual services. Write for Bulletin 5710.

DARLING VALVE & MANUFACTURING COMPANY Williamsport 23, Pa.

Manufactured in Canada by The Canada Valve & Hydrant Co., Ltd., Brantford 7, Ont.

How to Choose Waterstop for optimum performance in concrete joints

Basic Design And Resilience Most Important Factors



The principal function of waterstop is to keep concrete joints watertight where hydrostatic water pressure is present. To be effective, and to perform its function under widely varying conditions, the waterstop must:

1. Be designed in such a way that it will maintain a "pressure seal" when the joint is opened up or compressed, or when hydrostatic pressure is exerted against it.
2. Be made of a material that is inherently stable and resilient . . . that will retain its resiliency and strength under wide ranges of temperature.

There is general agreement by many governmental and private specifying authorities, after years of testing and actual installation, that the dumbbell design of waterstop (below) is mechanically superior to any which has been developed to date. The design provides a self-sealing action, because as the concrete contracts and the joint opens up, the outer edges of the dumbbell bulbs become more tightly engaged with the concrete, insuring a tighter seal as the tension increases, due to movement either in the joint or increasing water pressure on one side of the joint. In effect, the greater the longitudinal pull or pressure on one side, the more tightly the dumbbell ends are pulled and squeezed against the concrete. The simpler dumbbell design of the rubber waterstop allows full strength and contact with the concrete surrounding the waterstop. The larger design also provides for maximum strength to resist higher pressures on the web of the waterstop across the joint opening.



6" DUMBBELL TYPE EMBEDDED IN CONCRETE WITH A CONSTRUCTION JOINT



9" HOLLOW BULB TYPE EMBEDDED IN CONCRETE WITH AN EXPANSION JOINT

Rubber and vinyl are the most commonly used waterstop materials. For the majority of applications, rubber is the most satisfactory material. Being a thermosetting material, rubber is more resilient and "live" . . . will maintain a constant pull against the retaining edges (bulbs) as the joint opens up or water pressure increases. Vinyl is a thermoplastic compound and tends to take a "set" after it has been stretched, will float in the joint cavity, and have less resistance to the passage of water. When higher temperatures are present, such as in oil storage tanks, where oil is kept at temperatures around 150°F., the vinyl material, unless specifications are rigidly written, will soften and lose strength, causing a failure of the waterstop.

Field Splicing of Dumbbell Type

Servicised Products Corporation has developed a new Union which provides a simple method of joining the ends of dumbbell waterstops, making it just as fast and easy to field splice rubber and neoprene waterstop as the joining of the polyvinylchloride types.

The Union is made in the same cross-section, and from the same material as the waterstop. It is hollow, except for a solid web at the center. After adhesive is applied to the waterstop ends, they are inserted in the Union and pushed against the centering web. The splice is then clamped together until the adhesive has set. This completes the splice.

Dumbbell type rubber and neoprene waterstop are fully described in a special Waterstop Circular available from Servicised Products Corporation upon request. The Union and an interesting new development, Split Type, are also illustrated and described in the circular. Write for it today.

SERVICISED PRODUCTS CORPORATION
6051 W. 65th Street, Chicago 38, Illinois

FOR THE BEST IN Water Meters

go
ALL AMERICAN



AMERICAN METERS
Have Longer Life



Many American Meters in operation for 30, 35 years or more are still giving dependable accurate service. American Meters built today are so greatly improved that we know their period of service will be even longer. How much longer is difficult to estimate. It will depend entirely on the chemistry and the pH of the water to be measured and whether or not the metallurgy of the meter components has been tailored to meet the requirements.

Give Buffalo Meter Engineers full data on your water conditions and meters will be specified that will give longer life when you "go all American."

BUFFALO METER CO. 2914 MAIN STREET
BUFFALO 14, N. Y.

Planning a Water-Softening System in Your Plant?

If you are—or if your community already has such a system—here's some important data on regeneration of base-exchange zeolites and/or resins. This is the second of a series prepared by the International Salt Company, Inc.

How to find the strength of salt brine used in water-softener regeneration . . .

In most of today's plants, the type of hydrometer called a Salometer can generally be used to measure the strength of salt brines most accurately. This device (similar in principle to the hydrometer which checks the condition of your car's battery) is convenient to use—and its scale permits fast calculations. The scale reads from 0° in pure water to 100° in saturated brine . . . with each degree representing a percentage of fully saturated brine.

Using the Salometer with a maximum of accuracy, however, isn't just a matter of reading the scale. A number of simple precautions must also be taken to make sure the Salometer records correct brine strength. Here they are:

1. Check the temperature of the brine . . .

Since most Salometers are calibrated for reading at 60°F, brine temperature should be kept at this level during testing. When other brine temperatures are encountered, special tables of correction factors must be used. These tables are available from International Salt Company without cost.

2. Brine should be tested only in a straight-walled cylinder made of clear glass.

The cylinder should always be set on a level surface. Any moisture that collects on the outside of the cylinder should be wiped off before testing procedures start.

3. Salometer stem must be thoroughly dry . . .

It also must be clean, and free from grease or caked salt crystals. In addition, the Salometer should not touch the sides of the cylinder when readings are taken. It should be read with the stem in a vertical position.

4. Check new Salometers . . .

Do this by placing them first in clear water; reading should be 0°S. Then empty the cylinder, rinse with a saturated salt solution, and refill with fully saturated brine; reading should be 100°S. Water and brine should both be at 60°F.

5. Correct reading technique.

Brine tends to rise along the sides of a glass cylinder, forming a concave surface known as a meniscus. For correct reading, the eye should be brought to a point level with the bottom of the meniscus. Errors of two or three degrees are possible if reading is taken at the point where the brine has risen along the sides of the cylinder wall.

Salt—Plus Technical Service Available from International

Through skilled and experienced "Salt Specialists," we can help you get greater efficiency and economy from the salt or brine you use for regeneration. We produce both Sterling Evaporated and Sterling Rock Salt in all types and sizes. And we also make automatic dissolvers for both kinds of salt. So we can recommend the type and size of salt most perfectly suited to your needs.

If you'd like to get this technical assistance—or any further information—simply contact the nearest International sales office: Atlanta, Ga.; Chicago, Ill.; New Orleans, La.; Baltimore, Md.; Boston, Mass.; Detroit, Mich.; St. Louis, Mo.; Newark, N.J.; Buffalo, N.Y.; New York, N.Y.; Cincinnati, O.; Cleveland, O.; Philadelphia, Pa.; Pittsburgh, Pa.; Richmond, Va.

**INTERNATIONAL
SALT CO., INC.**

SCRANTON 2, PA.

Impact Insurance Against



- 1—LOSS OF FIRE PROTECTION.**
- 2—EXCAVATION AND PAVEMENT REPLACEMENT.**
- 3—COSTLY REPAIRS INVOLVING MAJOR HYDRANT COMPONENTS.**
- 4—FLOODING.**

The Smith Protectop Hydrant is designed to permit rapid return to service at minimum cost when a Hydrant is damaged as a result of a traffic accident.

The Protectop Hydrant Standpipe and Valve Stem are equipped with Special Couplings located just above the ground. The Couplings withstand operating pressures and ordinary impact with an ample factor of safety. Under excessive impact occasioned by traffic accidents the Couplings fracture at the design points thus minimizing the damage and permitting speedy return to service at low cost.

All Smith Hydrants are equipped with Compression Type Valves which definitely eliminate flooding since the line pressure holds the Valve against its seat in the closed position.

Write for details.

38



THE A.P. SMITH MFG. CO.
EAST ORANGE, NEW JERSEY

Water Supply A Problem?

*LARGE or SMALL
you can count on LAYNE!*

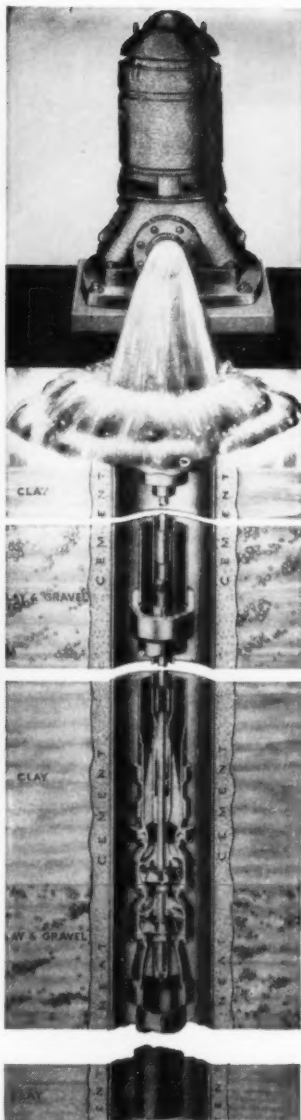


*A battery of Layne pumps installed
for the city of Mobile, Alabama.*

The size of a Layne pump will vary with the job it's required to do, but the workmanship in each is constant.

Whether the need is for 30 or 30,000 gallons . . . You can count on Layne!

Layne is concerned only with the unfailing and economical delivery of water in the required quantities and at the time specified . . . and you can count on Layne!



WATER WELLS • VERTICAL TURBINE PUMPS • WATER TREATMENT

LAYNE & BOWLER, INC. MEMPHIS


General Offices and Factory • Memphis 8, Tennessee

LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD







CORPORATION STOPS...

It Pays to Buy



High quality water service bronze, 85-5-5-5 mix . . .
 Plugs individually ground in for perfect fit . . .
 Corporation stops can be installed with any
 standard tapping machine . . .
 Threads interchangeable with those of other
 manufacturers . . .
 Conform to all A.W.W.A. standards.

*The same quality is maintained in the complete HAYS line
 of Water Service Products. Send for literature.*

 <p>COPPER METER SETTERS</p>	 <p>MODEL "B" TAPPING MACHINE</p>	 <p>DUO-STOP CORPORATION STOP and SADDLE COMBINED</p>  <p>ROUNDWAY CURB STOP</p>
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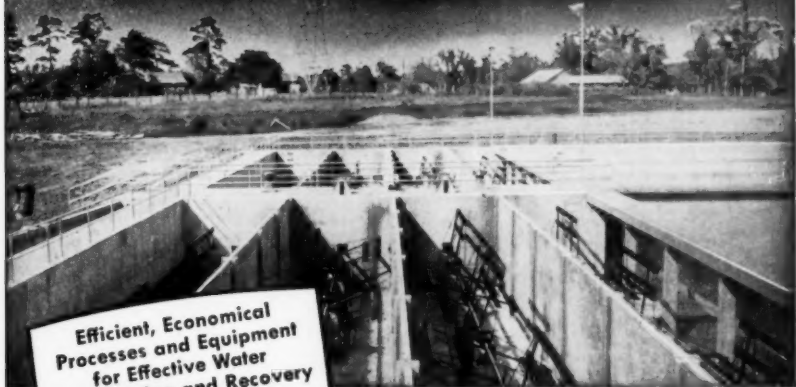
Join the A. W. W. A.
 HAYS is one of the eleven
 Charter Members of the
 Manufacturers Section of
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WATER WORKS PRODUCTS

HAYS MANUFACTURING CO.
 ERIE, PA.

IMPROVE Water Treatment with PROVED American EQUIPMENT



Efficient, Economical
Processes and Equipment
for Effective Water
Conditioning and Recovery

CONTINUOUS PIPELINE CHEMICAL MIXING

THE HOMOMIX—provides instant, violent, uniform, and complete mixing of one or more chemicals or gases with water—continuously or intermittently, *without the use of a mixing tank!*

Designed with one or more stages of direct-connected motor driven diffuser impellers rotating in blending chambers, it forms part of the influent piping. Discharges directly across the flow-through stream. Mixes instantaneously at the point of entry. Lift impeller can be added to provide additional head, if required. *Send for Technical Supplement HM and Bulletin 300.*

IRON AND CARBON DIOXIDE REMOVAL

THE FERROFILTER—removes iron, manganese, carbon dioxide, and other dissolved gases and odors—efficiently and economically, in one simple operation. Utilizes fine media in open aeration. *Write for Bulletin No. 252B.*

SOFTENING AND TURBIDITY REMOVAL

THE FLOCSETTLER—combines in one unit all modern concepts of water and waste treatment, including mixing and slurry blending, slurry recirculation, sludge blanket settling, sludge concentration, and sludge removal. *Send for Technical Supplement FL.*

RAPID MIX AND FLOCCULATION UNITS

PADDLE-PROPELLER-RM TYPE MIXERS—for rapid mixing to obtain continuous blending of chemical with raw water.

PADDLE-DOWNFLO-FLOCCULATION UNITS—designed to efficiently carry out the slow mixing and flocculation functions required in the coagulation process. Choice of vertical and horizontal units. *Send for Technical Supplement PF.*

SLUDGE REMOVAL

POSITIVE FLIGHT CONVEYORS—for rectangular settling tanks. Heavy-duty solid shafting, bab-bitted plate sprockets. Heavy adjustable self-aligning wall bearings, furnished with foundation bolts welded to templates and eccentric washers for economical installation.

CIRCULAR CLARIFIERS—Structural steel bridge, steel flights in staggered position mounted on two radial trussed arms driven by motorized gear reduction unit. *Write for Bulletin 253B.*

PUMPS

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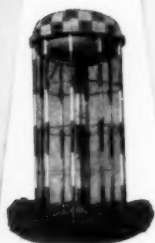
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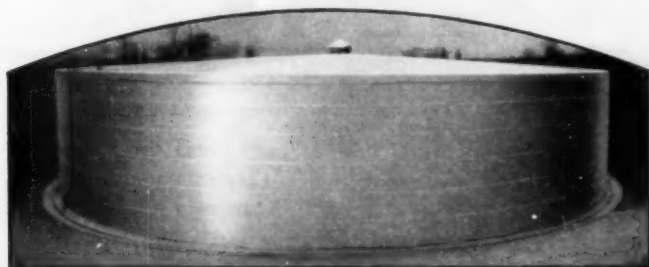
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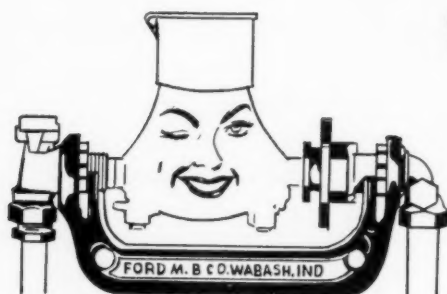
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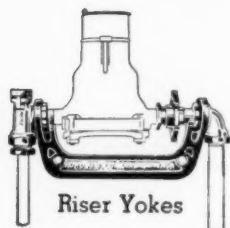




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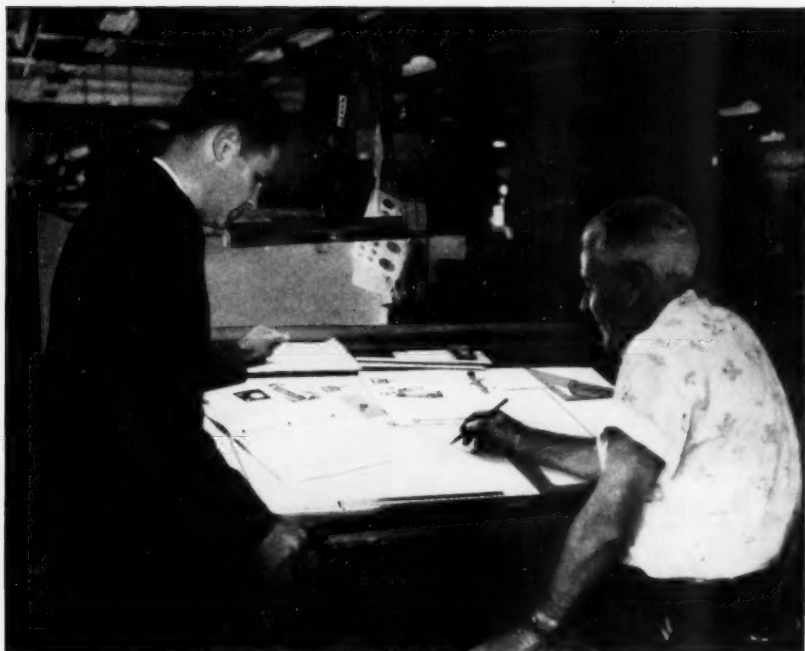
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Control of Odor and Taste in Water Supplies

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PROPER disinfection of water supplies has been so successful throughout the United States that citizens now expect a safe water without question. Public demand for a palatable water as well has resulted in greater attention to the correction of tastes and odors. Although many water plants are now delivering a consistently palatable water to their consumers, much remains to be done. Abel Wolman, (1) in his report on 75 years of water quality improvement, stated:

The road to universally palatable water, however, has been only partially traversed, even though suitable control methods are available. Some operators refuse to admit their responsibility to their consumers, while others laugh off complaints, and still others do not know that the water they are delivering is unpalatable. John Baylis' statement in 1924 is still applicable in many communities today and is worthy of repetition. "The removal or prevention of [objectionable tastes] should receive more consideration from our water works officials."

There are many progressive water works officials throughout the United States, however, who are showing an increasing willingness to spend whatever is necessary to reduce tastes and odors to palatable levels. During 1956 the city of Chicago (2) expended nearly \$150,000 for activated carbon to control tastes and odors at the South District Filtration Plant. This expenditure represented about 25 per cent of the entire chemical costs, whereas the cost of chlorine for disinfection was only 16 per cent. Thus, this plant is spending more money to accomplish water palatability than is necessary to make the water safe for human consumption. Responsible officials are so proud of their accomplishments that they have adopted the slogan, "Every Drop Pure and Palatable." Wide variations in activated carbon dosages are necessary to control fluctuations in odor types and intensities. The annual average dosage at the Chicago South District Plant was only 2.0

ppm, yet the maximum daily usage during 1956 was 47,080 lb, equivalent to 24 ppm. The daily average output of this plant during 1956 was 338 mgd.

Importance of Palatability

Flavor in the foods people eat and drink is determined by the combination of their senses of taste and smell, and the food industry is heeding public demand for products with the most satisfying flavor. Some companies have even developed flavor panels of several hundred people, widely dispersed throughout the country, in an effort to learn consumer preference for flavors in the foods they produce. By utilizing the information obtained, companies have been able to increase their sales appreciably.

The modern grocery store in the United States stocks many different brands of tomato juice from which the consumer may select the one he prefers for flavor. If none of these brands is acceptable, the consumer has additional choices of vegetable or fruit juices to satisfy his specific desires. The consuming public in the United States is demanding and buying those foods and beverages which are most pleasing to the senses of sight, taste, and smell. Costs seem of only secondary consideration, considering the wide acceptance of frozen foods and the continued purchase of coffee during the period of skyrocketing prices. Today, many housewives are purchasing a specific brand of soap merely because it, or the wrapper, happens to blend in with the color scheme of the bathroom, and cost is of practically no significance. Certainly, with such an attitude, the public cannot logically object to minor increases in water costs which will assure the delivery of a consistently palatable water.

In order to obtain opinions of leaders in the field, a questionnaire dealing with importance of water palatability was submitted to a selected group of state health officials. A number of the responses stressed that an unpalatable water could constitute a health menace if consumers were so dissatisfied that they would obtain drinking water from local springs or wells which, though more palatable, would be of questionable safety.

The practice of fluoridation of water supplies to aid in the reduction of dental caries has been adopted in a large number of communities throughout the United States. Effectiveness of the treatment depends upon a consistent and relatively uniform ingestion of the fluoridated water. Therefore, water palatability assumes major importance if the desired beneficial results are to be assured.

Except for air, water is the most vital requirement for human existence. Some members of the medical profession in the United States have advised that the normal individual should have a water intake of 2 qt of water per day. Complying with such advice would constitute no problem where a consistently palatable water was available.

Although the USPHS standards state "The water shall have no objectionable taste or odor," there appears to be considerable difference of opinion among state health officials regarding the legal requirements for water palatability. In the above-mentioned questionnaire, the state health officials were asked whether they would have the legal right to go into a treatment plant where unpalatable water was being supplied and insist on application of suitable corrective treatment. Fifty per cent answered yes, 30 per cent no, and the remainder were either uncertain or

would not give a definite answer. Thus, it would seem that there is no consistent action on the part of state health departments with regard to water palatability.

The problem of taste and odor correction has, therefore, remained predominantly at the local level, where great improvements have been accomplished. Whether motivated by consumer complaints or a sincere desire to deliver the best water quality possible, many local water works officials can now boast that their consumers are receiving palatable water from sources which are frequently subject to high concentrations of odorous substances. Concerted effort on the part of state departments could not help but aid materially the cause of universally palatable water.

Physiology

A new technique is now being used in the United States in an effort to determine how the senses of taste and smell function (3). This involves recording electrical responses of the taste cells, as well as the olfactory, by tapping into the specific nerve fibers. With the delicate instruments now available, it is possible to "listen in" on the messages as they are being carried to the brain.

From the experimental data, obtained from many different kinds of animals which were subjected to many tests, a theory has been developed on how people taste. The theory involves adsorption and ion-exchange principles, and an equation has been developed to cover various taste responses. These studies confirm the previous theory that there are only four taste sensations—salty, sweet, sour, and bitter—and that all other so-called tastes are actually odors.

Studies on the olfactory responses have just recently resulted in the development of methods of quantitative measurements, but a satisfactory theory has yet to be developed. Tests show that the trigeminal nerve fibers do not enter the mucous layer covering the olfactory epithelium. Since no specialized structures are known to exist at these nerve endings, just how they are stimulated by odors remains a mystery.

Such extensive studies would probably have greater significance for foods and beverages, where flavor is an essential factor. In their proper environment an individual can enjoy the aroma of fish, cucumber, geranium, and even newly mown hay; yet he would be highly critical of a potable water containing any of these odors.

The public expects water to be free from any detectable taste or odor when it is used for cooking, bathing, or drinking purposes. Thus, complete removal is not necessary, but taste- or odor-producing substances must be reduced to concentrations which are below detectable levels. Based on the fact that there are only four taste sensations, information later in this article will show that the predominant problems of water palatability in the United States are those of odors rather than tastes.

Summary of Questionnaires

The meeting of the International Water Supply Congress in May 1958 will include in its program a panel discussion on control of odor and taste in water supplies, and the author has been delegated as reporter for the United States on this subject. In order that the report be more than just one person's opinion, questionnaires were prepared on various phases of the subject for submittal to water works officials

concerned with the problem. Selection of individual plants was greatly simplified by data contained in a survey conducted by the USPHS, with the cooperation of state health departments, encompassing water facilities existing as of Jan. 1, 1955, in communities of 25,000 population or over. In summarizing data from this survey, Ralph Porges (4)* reported that 202 plants of a total of 570 were employing corrective treatments for taste and odor con-

ing a return of more than 65 per cent. Average daily pumpage for all of the plants totaled more than 5 bil gal. Thus, the average daily output was 20.7 mil gal, and the median daily output was 7.4 mil gal.

Some questionnaire responses indicated that tastes and odors no longer constituted a problem, and these were eliminated immediately. Therefore, all references to the questionnaires will involve only those actually having taste

TABLE 1
Successful Treatments of Tastes and Odors at 241 Plants

Cause	Plants		No. of Plants Employing Method Successfully*				
	No.	%	Activated Carbon	Free Residual Chlorination	Super Chlorination	Chlorine Dioxide	Aeration
Algae	198	82	163	17	7	6	5
Decaying vegetation	162	67	139	17	6	6	2
Trade wastes	92	38	56	12	3	26	3
Other	55	23	47	11	2	3	1
Percentage Employing Method Successfully†							
	No. of Plants						
Algae	198	82	8.6	3.5	3.0		2.5
Decaying vegetation	162	85	10.5	3.7	3.7		1.2
Trade wastes	92	61	13.0	3.3	28.2		3.3
Other	55	85	20.0	3.6	5.5		1.8

* Some plants have employed more than one method successfully in combating a particular cause of odor. Therefore, the total number of instances of successful treatment may exceed the number of plants reporting the specific cause.

† Percentage figures are based on number of plants reporting a particular cause, not the total 241. A total of percentages in any given row may exceed 100 per cent.

trol. These specific plants, therefore, constituted a core for development of the desired information. To broaden the scope of the coverage, questionnaires were submitted to additional plants where corrective treatments such as use of activated carbon, free residual chlorination, and chlorine dioxide had been utilized for improvement of water palatability. Responses were amazingly good, totaling 241 and represent-

and odor problems. Table 1 shows the summary of the number of plants reporting the cause of odors due to algae, decaying vegetation, trade wastes, and others. The table also shows the number of plants reporting successful treatments employed for correction of the specific sources of odor. The total of the individual treatments is greater than the number of plants reporting for the specific cause, because some plants reported more than one suc-

* See also this issue, p. 1567.

cessful treatment. For example, in the treatment of trade wastes some plants faced a variety of problems, and they therefore reported chlorine dioxide successful for some types and another treatment for others.

The most frequent cause of tastes and odors is algae, with decaying vegetation a rather close second. Table 1 shows these same results in percent-

age published in *Water Quality and Treatment* (5) those algal types for which characteristic odors were recorded. Responses to this algae questionnaire were less numerous, because some plants were not equipped to make microscopic examinations or had little concern because the water source was a stream or large lake where treatment would be impractical. Nevertheless,

TABLE 2
*Odor-producing Algae Reported **

Organism	Times Reported	Organism	Times Reported
<i>Diatomaceae</i>	321	<i>Chlorophyceae</i>	114
Asterionella	102	Dictyosphaerium	6
Cyclotella	29	Eudorina	16
Diatoma	42	Gloeocystis	9
Meridion	7	Hydrodictyon	5
Synedra	93	Nitella flexilis	0
Tabellaria	48	Pandorina	17
		Staurastrum	26
<i>Cyanophyceae</i>	198	Volvox	35
Anabaena	91		
Aphanizomenon	52	<i>Protozoa</i>	205
Clathrocystis	12	Bursaria	0
Coelosphaerium	29	Ceratium	33
Cylindrospermum	5	Cryptomonas	6
Rivularia	9	Dinobryon	48
		Glenodinium	13
<i>Fungi</i>	26	Mallomonas	23
Beggiatoa	6	Peridinium	16
Crenothrix	19	Synura	66
Sphaerotilis natans	1		

* Other organisms mentioned were: Anabaenopsis, Ankistrodesmus, Anuraea, Chlamydomonas (reported three times), Chlorella, Cladotrix, Codonella, Coelastrum, Cyclops, Daphnia, Euglena, Fragilaria (reported eight times), Gallionella, Leptothrix, Melosira (reported eleven times), Merismopedia, Micractinium, Microcystis (reported three times), Microspira, Navicula, Oedogonium, Oscillatoria (reported three times), Palmella, Pediatrum (reported nine times), Raphidomonas, Scenedesmus (reported five times), Sphaerozoysa, Spirophyllum, Stephanodiscus (reported four times), Stigeoclonium, Tetraspora, and Trachelomonas.

ages, and it will be noted that algae are reported by 82 per cent and decaying vegetation by 67 per cent.

Algae

Since algae are most frequent causes of tastes and odors, a separate questionnaire was submitted to those reporting algae as a problem. This questionnaire was developed by selecting from a

152 responses were received and Table 2 summarizes the data from those plants reporting experiences with the specific algal types.

The organisms most frequently reported at the Diatomaceae, with the Protozoa and the Cyanophyceae groups practically tied for second. Those in the fungi group are of only minor significance.

The individual algal types most frequently recorded are *Asterionella*, *Synedra*, and *Anabaena*. Somewhat less frequently mentioned are *Diatoma*, *Tabellaria*, *Aphanizomenon*, *Dinobryon*, and *Synura*. It is interesting to note that little or no mention was made of *Nitella flexilis*, *Bursaria*, and *Sphaerotilis natans*.

Provision was made in this questionnaire to write in other algal types responsible for tastes and odors. At the bottom of Table 2 those write-ins are listed.

This algae questionnaire also asked whether there was any disagreement

4. *Ceratium*: Several described the odor as cod liver oil or bitter.

Based on recent work in this country, J. K. G. Silvey (6) reports that actinomycetes are responsible for many odors encountered in raw water supplies. In fact it has been indicated that many of the odors attributed to algae are actually caused by growths of actinomycetes which are present in the water. Therefore, those answering the algae questionnaire were asked to express an opinion as to whether they agreed with this view. This concept appears to be too new for any final opinion since 40 voted yes, 39 voted no, and 32 had formed no opinion. Actinomycetes are extremely small organisms requiring much greater magnification than is required for microscopic examination of algae. Few water plant laboratories would be likely to have the necessary equipment for studies of actinomycetes, so the greater majority of views expressed are probably opinions based on experiences with algae rather than any actual data on actinomycetes.

TABLE 3

*Odor Types Due to Decaying Vegetation **

Characteristic Odor	No. of Plants Reporting
Musty	69
Earthy	28
Woody	20
Moldy	17
Swampy	12
Grassy	9
Fishy	8
Wet leaves	7

* Others mentioned to a lesser degree are septic, muddy, boggy, vegetable, phenol, peaty, rotten, putrid, soaked straw, very sour, varnish, barnyard, and horse urine.

as to the character of odor associated with the individual algal types. Predominantly there was agreement with the characteristic odors with but a few exceptions, as follows:

1. *Asterionella*: A number reported experiencing the fishy odor, without encountering the aromatic or geranium odor.

2. *Anabaena*: One reported this to give a geranium odor, while several reported the odor to be vile pigpen.

3. *Aphanizomenon*: Several different descriptions were offered for odors associated with this type, including nasturtium, pigpen, dry musty, and corn husks.

Decaying Vegetation

Odors under the classification of decaying vegetation derive from: decaying algae, leaves, weeds, or grass; seepage from stagnant areas into reservoirs or streams; flushing of stagnant areas and farm land during spring freshets or heavy rainfall periods; and any disturbance of bottom deposits in streams or impounded supplies due to sudden raising or lowering of the water level.

Many reported the types of odors arising from decaying vegetation, and these are summarized in Table 3. It will be noted that the most prevalent descriptive term is musty, while the anticipated descriptions of swampy, wet leaves, and moldy, fall far behind. A close examination of the descriptive

terms at the bottom of the table will indicate the imaginative character of some of the observers. It is quite within the realm of possibility that many of these odors may actually be due to the presence of actinomycetes.

Trade Wastes and Others

Table 4 shows types of trade wastes causing tastes and odors in water supplies. Phenol is reported most frequently, with chemical second. Trade wastes occur less frequently than odors of natural origin, but often give rise to extremely high odor concentrations. Some of these odors are more difficult to adsorb on activated carbon, so higher dosages are required.

TABLE 4
*Frequency of Trade Wastes Causing Odors **

Types of Waste	No. of Plants Reporting
Phenol	38
Chemical	20
Petroleum oil or oil refinery	18

* Others less frequently mentioned are dairies, corn sugar plants, canneries, mine wastes, sulfite paper mills, and vitamin wastes.

The most frequent listing in the classification of other causes is sewage, with 22 reporting. Second is the muddy earthy type odor associated with high turbidity, with nine reporting. Less frequently listed are synthetic detergents, actinomycetes, dairy farms, fish, and silt and mud deposits.

Deoxygenation

Of 159 plants reporting on the question of deoxygenation, only 31 reported having odor problems. Many of the reporting plants, however, derive their water from streams and shallow reservoirs, where such a problem would not exist. According to some comments, a flat, earthy taste developed under a heavy ice coating at several locations, and odor was eliminated by activated

carbon or aeration. Many reported development of septic or hydrogen sulfide odors, and some a swampy odor. One plant reported that a cool rain and hail storm broke up the thermocline, giving rise to fishy, haylike, musty, and earthy odors.

Odors Within Plants

Only about 30 per cent of the 159 reporting plants reported the development of odors within the treatment plant, and many of these have been eliminated by various means. The greater majority reported facing difficulties with decomposing sludge in settling basins. Corrective measures include more frequent cleanings, installation of sludge removal equipment, feeding activated carbon or chlorine at the basin influents, and the addition of carbon when refilling basins. Algae have been reported to develop in pre-settling basins, and copper sulfate was the corrective treatment.

Very few reported any problems with odor development in the filters. Instances involved overchlorination of water entering the filters and algae or decomposing sludge on the filters. One report indicated that the application of ammonia ahead of filtration, followed by postchlorination, gave rise to a serious algae problem in the filters. This was corrected by moving the point of chlorine application ahead of the filters. Isolated examples of odor development within the treatment plant include improper combustion of the carbon dioxide producer, temperature turnover of water in the basins, recirculation of primary sludge, and lime softening giving a strong fishy odor.

Underground Supplies

The presence of dissolved minerals in underground water supplies poses a taste problem in some water supplies.

In general, most sections of the United States have little difficulty, but there are a few localized sections where such problems exist. A great majority are caused by the dissolving of minerals from the underground strata, resulting in high chlorides, sulfates, hydrogen sulfide and iron. Also, some few cases of salinity due to salt water intrusion have occurred. A great majority of waters giving difficulty with iron and hydrogen sulfide are suitably treated by aeration, followed by either chlorination or retention for completion of oxidation. No economically successful treatments for chlorides or sulfates have been reported. Some communities develop a tolerance for slight mineral tastes, but where such tastes are very severe, those supplies are almost always abandoned in favor of more palatable ones.

Demands for water are pyramiding because of increased population, greater per capita consumption, and shifts of population away from urban areas. Underground water sources are so depleted in some populous areas that additional demands will have to be met by resorting to surface supplies, which will probably require treatment for correction of tastes and odors.

Treatment and Distribution

The greater number, 69 per cent of 159 plants, reported development of odors or tastes due to treatment chemicals. Seventy-nine per cent of the plants having problems reported chlorinous odors. Many of these have corrected the conditions by using chlorine with ammonia, activated carbon, closer control of chlorine residuals, or dechlorination. Thirty-nine per cent reported medicinal odors due to chlorophenols, and 15 per cent reported odors due to nitrogen trichloride. Other chemical

influences were chloralgal odors, fixation of odors by lime, hop odor from carbon dioxide, and bitter taste due to chlorine reaction with detergents. Suggestions offered in cases of chlorinous odors were to let water run a few seconds and to let water stand for a few minutes.

Of 159 water supplies reporting, only 49 per cent reported having problems of tastes and odors arising in distribution systems. The preponderance of odor problems within the distribution system occur in low-velocity areas and were usually successfully corrected by a suitable flushing program. Less than 15 per cent of those reporting indicated problems caused by pipe coatings or organic growths in the pipelines. Of very minor significance is the development of odors in new iron or cement pipes, sloughing off of deposits, tank coatings, algae in reservoirs, and disinfection procedures on new distribution lines.

Detection and Measurement

Of 241 plants reporting on odor evaluations, approximately 82 per cent run odor tests, and most of these run tests daily or more frequently.

Standard Methods (7) describes two basic procedures for odor evaluation. One procedure merely involves estimation of the odor, either hot or cold, whereby the odor intensity is given a value expressed in Roman numerals. A zero denotes a completely palatable water, and a value of V is a water so unpalatable that no one will drink it. Approximately 31 per cent of the reporting plants utilize this procedure.

The other standard procedure is the threshold dilution method, wherein samples of water are diluted with increasing amounts of odor-free water

until that dilution is obtained at which the odor is just detectable; 42 per cent of the reporting plants utilize this technique. The threshold odor number is obtained by dividing the total volume of the sample by the volume of odorous water contained therein. Thus an odor number is determined, which represents an actual measure of the odor concentration. In this test the water is usually carried to a temperature of 60°C in order to secure as high an odor value as possible. A threshold odor number of 2 is nearly always within palatable limits, and in the majority of cases a threshold number of 5 will constitute a palatable water. Sometimes, although odor concentrations are well within palatable limits, complaints associated with the sense of smell are still made. At such times appreciably lower threshold odor values must be reached in order to assure a palatable water.

Where taste tests are conducted, dilution procedures similar to the threshold odor technique are employed. Temperature of the water is usually kept at tap water temperature, although some few plants do utilize an elevated temperature.

The highest threshold odor numbers reported in the questionnaires were 12,500 and 6,000, but the mean maximum odor of raw water was only 30. The worst raw water had an annual average odor of 726, whereas the mean annual average of all plants was only eight.

For delivered water the highest mentioned was 278, with a mean maximum of 5. Thus, 50 per cent of the 90 plants reporting odor values are probably delivering a consistently palatable water. On an annual average basis, the highest reported value for delivered water was 19, with the mean at 2.

The maximum odor value is of greatest importance, because the average citizen in the United States will not soon forget the existence of an objectionable taste or odor in his water supply.

Corrective Measures

In the author's experience, first action for dealing with tastes and odors is for the treatment plant to institute chemical applications which are most likely to produce palatability, such as feeding the maximum possible amount of activated carbon, or adjustment of dosages of other chemicals to accomplish correction of the condition.

The next step is laboratory work to determine the most economical measures. A quantity of tap water containing the odor is dechlorinated for taste tests by a panel of observers, to determine the degree of odor removal necessary to reach palatable limits. Dilutions (20, 40, 60, 80, 90, and 100 per cent) of this dechlorinated water are prepared with odor-free water. These dilutions, at tap water temperatures, are tasted by several observers, starting with 100 per cent odor-free water and proceeding in the order of increasing amounts of tap water. Each observer tastes succeeding dilutions until he reaches the sample he considers unacceptable. The sample just previously tasted would thus constitute the acceptable palatability level for the specific observer. Based on observations of the panel, that dilution is selected which is acceptable to the greatest proportion of the observers, and the threshold odor of this dilution is determined to find what value must be reached in plant scale operations.

Laboratory tests are next conducted on raw-water samples with varying dosages of activated carbon (2, 5, 10,

and 20 ppm for low-odor concentrations; or 10, 20, 40, and 80 ppm for high), and the usual chemicals and treatments are employed to simulate plant operations. After filtration, threshold odors are run on each sample, and results plotted to determine the activated-carbon dosage necessary to obtain the previously determined threshold odor value for palatability. Since adsorption by activated carbon is much better on a large scale than in laboratory tests, only half the required laboratory dosage is applied in the plant. This dosage can then be altered to conform with plant results.

The above tests presume that existing points and order of chemical application will give optimum results. Complete studies would include an investigation to determine the influence of other chemicals, bearing in mind the following:

1. Chlorination can either reduce or intensify odors.
2. Better adsorption is usually obtainable if the odorous compound has not had an opportunity to react with chlorine.
3. Lime or other chemicals for pH adjustment can influence palatability.
4. For best results carbon should be applied to water having pH values below 8.5-9.0.

The city of Hammond, Ind. (8), employs a control system which has resulted in a 3-year period of operation without a complaint on taste or odor. Raw water is obtained from one of the Great Lakes, and odor sources originate on both sides of the intake. Thus, the specific odor to be treated depends upon the wind, and a sudden change in wind direction can completely change the odor conditions to be handled. Furthermore, the odor

concentration has varied from 20 to 500 threshold odor units.

From actual plant experience graphs have been developed showing the activated carbon dosage necessary to control various intensities of each specific type of odor. Based on hourly threshold odor tests of incoming water, the dosage determined from the graph is applied to the raw water.

Hourly threshold odor tests are also conducted on samples collected at various points in the treatment plant. If the threshold value of water entering the filters is 3 or more, additional activated carbon is applied to the filter influent, and the dosage to the raw water is increased. As soon as the odor in the settling basin returns to normal, the application to the filter influent is discontinued. Activated carbon dosages at Hammond average 10 ppm, with a maximum of 125 ppm.

Preventive Measures

Many preventive measures are utilized to varying degrees for the control of tastes and odors. Copper sulfate is widely used for the control of algae growths, not only in impounded water supplies but also on occasion in settling basins within the plant and in open reservoirs on distribution systems. Decaying vegetation odors have been reduced in some cases by elimination of swampy areas on watersheds, either by dredging, draining, or damming off such areas from the main water supply. The greatest amount of effort, however, recently has been directed toward treatment of domestic and industrial wastes. Health authorities in the various states have been extremely active and much more insistent on proper treatment for domestic sewage which is discharged to a stream later used for potable purposes. To-

ward this end, the US Congress passed Public Law 660, authorizing federal grants of \$500,000,000 for construction of sewage treatment plants. Many of the states have pollution control commissions, but the authority to act appears to be quite variable, depending upon the state laws involved and also upon individual watershed areas within the specific states. Some individual water departments have also taken steps to control the discharge of objectionable industrial wastes within their watershed area. Some of the results have been quite successful. One stream which was rapidly reaching the condition where it would be condemned as a public water supply is today so greatly improved that catfish and carp are now thriving where they were non-existent for a period of at least 20 years. Naturally, the water quality at the plant intake was greatly improved and more amenable to treatment.

Application of chlorine gas at water depths up to 85 ft or chlorine solutions at greater depths were successful at Los Angeles, Calif., in appreciably reducing the tastes and odors developed in deoxygenated areas of deep reservoirs. Presence of chlorine or dissolved oxygen prevented anaerobic conditions in the thermocline area.

Chlorine gas was applied from the shore through small-diameter ($\frac{1}{4}$ in.) black-iron pipe to a diffuser near the deepest point in the reservoir. Based on the amount of water in the thermocline area, chlorine dosages were quite high, but not unreasonable, considering the total water volume (9).

A specially designed aeration device (10) has been used successfully to break up stratification in a reservoir. Air was released through spargers 8 ft below the water surface at a rate of 160 cfm. The total 80 mil gal in the

reservoir was theoretically turned over in about 13 hours, but complete elimination of stratification was only accomplished after a 7-day period of operation, as measured by uniform water temperature and dissolved oxygen. This result permitted use of water from all depths of the reservoir.

The questionnaire submitted listed treatments as follows: activated carbon, free residual chlorination, superchlorination, chlorine dioxide, ozone, aeration, and others. Individuals were asked to check various treatments tried and to comment on the results obtained. A few failed to furnish the desired details, but the great majority were very cooperative.

The answers are summarized in Table 5. The first column shows the total number of plants reporting for the particular causes of odors. Succeeding columns record the degree of success reported for all listed treatments except ozone. Under the individual treatment, the first column shows those reporting complete success; the second column, partial success; and the third column, no success.

Activated Carbon

Powdered activated carbon was first applied in a public water supply in the United States in 1929, and was accepted almost immediately as a method for the control of odors in water supplies. Results shown in Table 5 indicate its success on the entire gamut of odors encountered. Some of those reporting partial success indicated reasons, such as inability to apply carbon at the proper point, or inability to apply sufficient carbon because of inadequate facilities within the treatment plant.

During the early development of powdered activated carbon, postchlori-

TABLE 5

Causes of Odors	No. of Plants Reporting	Activated Carbon (221)						Free Residual Chlorination (158)					
		Total		Partial		None		Total		Partial		None	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Algae	198	163	90	17	9	2	1	17	13	56	44	54	42
Decaying vegetation	162	139	92	11	7	1	1	17	16	46	43	44	41
Trade wastes	92	56	68	23	28	3	4	12	19	22	35	28	45
Other	55	47	87	5	9	2	4	11	28	12	31	16	41
<i>Overall summary</i>	507	405	86	56	12	8	2	57	17	136	41	142	42

* Percentage figures are based only on those plants that reported having tried the specific treatment on the particular cause of odor. For example, on other causes of odor, chlorine dioxide was tried by 21 plants; therefore,

nation was the common practice, so results with carbon were very successful. With the advent of prechlorination, however, many plants fed activated carbon and chlorine at the same point, with a resulting loss in effectiveness of both chemicals. In spite of a wealth of literature recommending separation of points of application, questionnaire responses indicate that 35 per cent of the reporting plants are still applying the two chemicals at approximately the same point. The reason is perhaps less due to lack of knowledge than to inability to do otherwise, because of existing plant designs.

Application of carbon ahead of chlorine appears to offer the advantages of more successful adsorption of odors and an appreciable reduction in chlorine demand. Some 37 per cent of the reporting plants have adopted this order of chemical application.

Conversely, 28 per cent of the reporting plants are applying chlorine prior to carbon. Many of these report a long time interval, with a mean of 90 min between points of application. With such time intervals the interference factor would probably be of minor significance. Nevertheless, in

such plants the potential of reduced chlorine demand by reversing the order of application should justify further study.

The highest reported dosage of powdered activated carbon was 180 ppm, with a mean maximum dosage of 30 ppm. Based on an overall yearly usage the average dosage was 2.1 ppm and the median was 2.0 ppm. As many plants do not use activated carbon continuously, a more representative figure when odors are present would be 3-4 ppm.

Free Residual Chlorination

Although the principle of free residual chlorination was developed by N. J. Howard (11), in Toronto, Ont., in 1929, application in the United States was not adopted until 1939 or 1940. Its acceptance is evidenced by the fact that more than 65 per cent of the reporting plants use or have tried this treatment. Individuals reporting on the questionnaire were requested to limit remarks to influence of the treatment on odors, and results of their replies are also shown in Table 5. It must, therefore, be realized that many plants in the United States utilize this

*Degrees of Success With Corrective Treatments, Reported by 241 US Plants **

Super- and Dechlorination (34)						Chlorine Dioxide (70)						Aeration (55)					
Total		Partial		None		Total		Partial		None		Total		Partial		None	
No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
7	24	12	41	10	34	6	13	12	25	30	62	5	11	24	53	16	36
6	30	5	25	9	45	6	14	8	19	28	67	2	6	18	47	18	47
3	17	6	33	9	50	26	49	13	24	14	26	3	14	9	43	9	43
2	20	3	30	5	50	3	14	2	10	16	76	1	7	7	50	6	43
18	23	26	34	33	43	41	25	35	21	88	54	11	9	58	49	49	42

percentage calculations were based on 21, rather than the total 55 reporting that type of odor. Numbers in parentheses after types of treatments represent the total number of plants that tried a specific treatment to combat one or more causes of odor.

treatment for its other advantages, such as better disinfection and improvements in plant operation. Complete success in reducing odors to palatable levels is reported by 28 per cent or less. Best results appear to be obtained with the sewage and sulfide odors, reported in the unclassified grouping, Table 1.

Reports on the merit of free residual chlorination were quite varied, and sometimes difficult to classify. Those recorded as partially successful reported as follows: [1] odor reduced but not to palatable levels; [2] odor sometimes removed but not always; and [3] odor sometimes reduced, other times intensified.

Most of those reporting partial success are practicing free residual chlorination predominantly for its other merits, but also take advantage of what it can accomplish for odor improvement. A few plants report discontinuing free residual chlorination when the odor is intensified.

The majority of those reporting unsuccessful results have discontinued this treatment, although a few practice free residual chlorination in the treatment plant, and then convert to a com-

bined residual by adding ammonia before delivery to the distribution system.

Other Methods

Only 34 plants reported using or having tried super chlorination, so caution should be used in drawing conclusions. Percentage calculations would indicate slightly better success with super chlorination than was reported for free residual chlorination.

The use of chlorine dioxide was first employed in the water field in the United States in 1944, and is formed in the treatment plant by reaction of chlorine and sodium chlorite. The summary in Table 5 indicates limited success with this treatment except on odors of trade waste origin, most of which were phenolic in nature, on which 49 per cent reported complete success. Rarely did any reports indicate lack of success on phenol or phenolic-type compounds, so chlorine dioxide can be considered particularly useful in handling such odors.

Less than 25 per cent of those returning questionnaires reported using aeration. A minor percentage recorded complete success, and it is prob-

able that in such instances the odor concentration was usually at low levels. The general view is that aeration will reduce odor concentrations by only 10-20 per cent, unless they are extremely volatile, such as hydrogen sulfide and sewage-type odors. In one case high-pressure aeration was very helpful in accomplishing a reduction of odors due to trade wastes.

Although ozone was listed in the questionnaire, only 8 plants reported using or having tried this treatment, so it would be unfair to draw conclusions from such a limited number.

A few plants reported employing marginal chlorination for odor improvement, and a somewhat larger number mentioned the use of copper sulfate for control of algal odors. Two plants reported shutting down their operations during odor surges.

Thirty-four plants volunteered the information that chlorine-ammonia treatment is employed, sometimes only as a post treatment, yet in other cases combined chlorine residuals are carried throughout the entire treatment plant and distribution system. Questionnaire responses would indicate that chlorine-ammonia treatment has definite merit as an aid toward delivery of palatable water, and several plants reported utilizing it to eliminate instances of chlorinous, nitrogen trichloride, or chlorophenol odors.

Conclusions

Although great strides have been made within the United States in the production of consistently palatable water, many communities are failing in their obligation to their consumers.

Algae are the most frequent cause of odors in water supplies, with decaying vegetation a close second. Trade

wastes, although they occur less frequently, can be much more troublesome.

Algae types most frequently causing odor problems are *Anabaena*, *Aphanizomenon*, *Asterionella*, *Diatoma*, *Dinobryon*, *Synedra*, *Synura*, and *Tabellaria*.

Tastes and odors due to dissolved minerals from underground strata constitute no problem except in certain localized areas. In surface waters the predominant problem is odor rather than taste.

Chlorinous odors continue to be a serious issue, and return to the use of chlorine-ammonia treatment for improvement of water palatability appears to be a growing trend.

Greater importance of palatability is demonstrated by the wider adoption of the threshold dilution procedure for odor evaluation.

Preventive measures, except for control of algae with copper sulfate, are employed very infrequently.

Reports of completely successful corrective treatments show activated carbon far in the lead with an overall effectiveness of 86 per cent compared with 25 per cent for chlorine dioxide, 23 per cent for super- and dechlorination, 17 per cent for free residual chlorination, and 9 per cent for aeration.

The proper point of carbon application in relation to chlorine and pH adjustment chemicals is deserving of further attention in water treatment practices.

From the viewpoint of public health and consumer relationship, water palatability has great significance, and the delivery of a consistently palatable water at all times should be the goal of all progressive individuals in the water works profession.

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Progress Toward AWWA Certification Program

In the description of the proposed AWWA certification program in the August 1957 issue of *Willing Water* (No. 47), it was indicated that members would be kept informed of progress. Although final action is not contemplated until the Board of Directors has had an opportunity to discuss the latest recommendations for the program at its annual meeting in January 1958, definite progress has been made: legal studies of the various alternatives have been completed and the officers and directors are now giving intensive study to the practical administrative features of the program. To clarify the status of the matter at the present time, however, the Executive Committee wishes to emphasize that *to date no AWWA certification program has been adopted*.

Survey of Water Purification Practice in Canada

—DeLoss H. Matheson and A. V. Forde—

A paper presented on June 19, 1957, at the Canadian Section Meeting, Winnipeg, Man., by DeLoss H. Matheson, Director, and A. V. Forde, Chemist, both of Municipal Labs., Hamilton, Ont.

THE purpose of this article is to present the experience of water purification plant operators in Canada in a form that will provide at least some suggestions for future development. Specifically, this article was prepared to survey the methods of water purification used in Canada and to evaluate their effectiveness. Thus, it supplements the article by Berry and Galimberti in 1954 (1), which surveyed the equipment and design factors in Canadian water treatment plants.

Questionnaires were sent to over 220 water treatment plants in municipalities of over 1,000 population where more extensive treatment than simple chlorination was practiced. Replies were received from somewhat less than one-half of the questionnaires. Most of the municipalities not replying were the smaller ones of population less than 10,000, and they may well have thought that the experiences of their small operations were not significant. These smaller water works frequently have little or nothing in the nature of instruments or test equipment; the plant equipment is installed by others, and the operation is by rule of thumb, directed as required in emergencies by provincial health departments. Nevertheless, it is worth noting that in some of these smaller plants the most enterprising operators have been found who,

with limited opportunities and facilities, have had the courage and resourcefulness to tackle problems and to experiment with radical treatments. Manufacturers and suppliers cooperate to a high degree and in a most useful way in providing technical direction in the installation and operation of new processes. Small water works have one additional advantage, in that they can conduct plant scale experiments at a reasonable cost, which cannot be done so readily in large works.

This article is not concerned with a survey of plant equipment, but the facilities available in each case have been considered in connection with the treatment processes.

Coagulation

The importance of the proper preparation of water before filtration is gaining in appreciation. A large portion of the turbidity and color can thus be removed by efficient coagulation and sedimentation, leaving only a relatively small portion to be removed by the filters.

Alum is by far the most extensively used coagulant. Only four plants reported the use of other materials. Sodium aluminate is used at Saskatoon, Sask., and Taber, Alta., and sodium aluminate with alum is used at Picton, Ont., and Malartic, Que. At the latter

plant 35.8 ppm of alum and 3.6 ppm of sodium aluminate produced better coagulation than a larger dose of alum alone. One municipality which did not report in this survey is said to be using an aluminoferric compound.

Liquid alum is now being used in a few plants where it offers certain advantages. The fact that it contains only about 50 per cent as much aluminum oxide as solid alum restricts its use to points within economical hauling distance of the manufacturing plant. The cost of installing corrosion-resistant storage tanks and piping is a considerable item in considering its usefulness. Against this may be offset the fact that it is cleaner to use, it requires no unloading and subsequent handling on the part of the water plant operator, and it is readily fed to the water by orifices, rotameters, or metering pumps. At Welland, Ont., which is very near the manufacturing plant, there is a substantial saving in the cost per ton on the dry-weight basis. The largest user will probably be the Brantford, Ont., water works where it is being installed at present. Toronto Township, on Lake Ontario, is also seriously considering its use.

The dosage of alum used varies over a very wide range, from a very few parts per million to a high of 170 ppm in very turbid waters at Lethbridge, Alta. In most cases the optimum dosages appear to have been determined on the basis of plant experience, although seven plants report using jar tests for this purpose.

A number of plants, including the largest ones, dispense with the use of alum during periods when the raw water turbidity is low. It has been found that the filters, without coagulant, are able to handle low turbidities and produce filtered water of acceptable

quality, effecting not only a saving in alum cost, but also avoiding the difficulty of greatly shortened filter runs due to the poor flocculation which occurs in clear waters. This practice is followed at the large filter plants in metropolitan Toronto, and has been used for 20 years at the Hamilton filtration plant. For many years alum application was started at Hamilton when the turbidity reached 10 units; lately it has been started at a turbidity of 5 units to improve the quality of the filtered water. Other plants report that alum is not used until the turbidity reaches 20, and at Montreal, where the maximum turbidity is about 20, no alum is used at all.

At Windsor, Ont., a period of low turbidity resulting in poor coagulation is experienced in spring and fall. Mechanical mixers have been advantageous in promoting floc formation, and it has been found that when the basins are partially filled with sludge a heavier floc is obtained with reasonable alum dosages.

Alum dosages are generally proportioned in some way to the turbidity or color of the raw water. For example, at Lethbridge where a wide range of turbidity occurs, alum is applied at the rate of 14 ppm for each 100 ppm of turbidity, up to a maximum of 170 ppm. In other cities where lower turbidities prevail, treatment may begin at less than 14 ppm.

In many smaller municipalities no equipment is provided for measuring turbidity or color, and the coagulant dose is maintained at a constant rate, or is adjusted by visual observation of the appearance of the incoming water.

At Brantford, Ont., and a few smaller works the appearance and settling properties of the floc itself are used directly to determine the coagulant

dose. In only one case (Windsor, Ont.) was it reported that the turbidity of the filtered water was used directly as a control factor.

Turbidity and color-measuring devices which have been mentioned range from the simplest visual means to automatic recording equipment. Four plants, including metropolitan Toronto's large plants, rely on bottled turbidity standards. Four plants use candle turbidimeters, one plant uses the platinum wire method, and two others use visual or photoelectric colorimeters.

At Hamilton, Ont., a continuously recording photoelectric turbidimeter has been used on the raw water for several years, and at Edmonton, Alta., recording turbidimeters are being installed. In view of the fact that there are available a number of turbidity measuring instruments which are inexpensive and easy to use, it is surprising that so many plants have to operate without their aid.

Measurement of the turbidity of filtered water is a more difficult matter, and is regularly performed at only a few plants. The instruments used are visual and photoelectric turbidimeters and bottled standards.

Coagulant Aids

In line with the increasing importance attached to water preparation before filtration a number of methods of improving coagulation have become available in the last few years. These aids act in two different ways: by increasing the strength of the floc, and by causing it to settle more readily. There are applications in many plants of these methods, and others have them under study.

Prechlorination was advocated for improving coagulation many years ago, but in this survey only four plants re-

ported its use primarily for this purpose. At Brantford, Ont., laboratory and plant tests showed that prechlorination did not aid coagulation, but a high level of free residual prechlorination decidedly aids in maintaining filters in a desirably clean condition. Other plants use prechlorination for other reasons, but indicate that some improvement in coagulation also results. In plants where severe difficulties due to algae are experienced, heavy prechlorination undoubtedly improves the coagulation and sedimentation of these organisms.

The use of the addition of clay to aid in flocculation of clear waters and to promote sedimentation by weighting the floc has been reported upon very favorably in several American plants, but in this survey only two plants mentioned its use. At Melartic, Que., two types of clay were used in a precipitator without producing sufficient improvement to justify the high cost. At Brandon, Man., clay is used during periods of low temperature and low turbidities to hold the floc down in a suspended-solids contact basin. It has definitely proved beneficial when used in large enough quantities (12 ppm or more). The clay is gathered locally, the material which creates the highest turbidity being chosen. At Kingston, Ont., the use of bentonite clay is now contemplated.

The use of activated-silica sols at dosages of 3-10 ppm is valuable in producing a heavier, tougher, and better settling floc, and is used or planned in nine reporting Canadian plants. It is known that in some cases its use results in shortened filter runs, but none of the plants presently using the process has commented on this aspect of the treatment, although this effect may have occurred to some degree.

Almost every possible activating agent is represented in the plants which use silica sols. At Smith Falls, Ont., silica is activated by alum, and is used seasonally during periods of high color and low temperature. At Brandon, Man., chlorine-activated silica has been used continuously for about 1 year with satisfactory results. Its use permitted an increase in the flow through the solids contact basin and allowed some reduction in alum dosage at higher water temperatures. At Brantford, Ont., silica activated with chlorine has been proved advantageous on a laboratory scale, and plant use is anticipated. At Malartic, Que., silica activated by ammonium sulfate gave good results in plant use some years ago, but resulted in shortened filter runs. Its use was discontinued due to other plant changes, but is being reconsidered now. At the Moose Jaw, Regina, Sask., plant, silica activated by sulfuric acid is used continuously. At Dundas, Ont., silica activated by sodium bicarbonate is used in coagulating a colored water, and by greatly improving coagulation it permits the operation of the plant at much above rated capacity.

There are certain proprietary organic materials available now, which hold considerable promise in improving water coagulation. They are widely used in industrial water and waste treatment processes to aid flocculation, and their effect is quite striking. Although they are said to have passed toxicity tests, their use in potable waters has not received state- or provincewide approval; the one plant-scale test in Canada was permitted by special arrangement with the Quebec Department of Health.

At Malartic, Que., jar tests indicated that 1-2 ppm of a coagulant aid in addition to the existing treatment would improve floc size, settling rate,

and color removal to a high degree. Plant-scale experiments were not as decisive as the jar tests in respect to settling rates, but this may have been due to the differences in mixing. The improvement in color removal, however, was especially noticeable.

At Wainwright, Alta., and at Hamilton, Ont., jar tests have been mentioned, using two other coagulant aids. These substances are quite expensive at the present time, and the desirability of using them in potable water is questionable,* but they constitute a most interesting field for experimentation.

Algae Control

The presence of large growths of algae in raw-water supplies profoundly affects the operation of filtration plants. Where the supply is from a relatively small body of water—a small lake or impoundment—control of algae growth by the use of algicides is practicable. At Dundas, Ont., copper sulfate is applied at frequent intervals to the water above a dam, to stop the growth of algae. At the Moose Jaw-Regina Sask., plant it has been proposed to use a copper citrate preparation from which insoluble copper carbonate does not precipitate as quickly as it does from copper sulfate. At Chatham, Ont., open settling basins are treated with copper sulfate.

Once the algae-containing water has entered the treatment plant there is little that can be done to reduce the effect of algae on filtration. Heavy

* The USPHS has established a Technical Advisory Committee on Coagulant Aids for Water Treatment to review and analyze information on the composition and toxicity of such materials and to advise on their safety for use in potable-water treatment. It is suggested that no material be used that has not been cleared by action of the committee.—Ed.

prechlorination is of value in some cases, depending on the specific organisms concerned. Copper sulfate treatment in the plant is of little value, as experiments at Hamilton have shown, but at Weyburn, Sask., its use is reported to have given satisfactory results.

A new method of dealing with the problem of algae in water—the removal of the organisms by microscreening—is attracting considerable interest at the present time. Extensive experiments with a pilot microscreening plant have been carried out at Belleville, Ont., where the algae problem is especially severe (2). Plankton removal was very high (95–99 per cent) and all organisms, even the soft-bodied ones, were removed equally well. Microscreening before conventional treatment would have the advantage of removing most of the filter blocking organisms, reducing chlorine demand by removing a large proportion of the organic matter, and it could make considerable improvement in taste and odor where these are caused by the action of chlorine on the algae. Microscreening also has a field of usefulness as the sole treatment by removing algae from clear waters which do not require filtration. In addition to the test at Belleville, microscreening tests are planned or in progress at several other Ontario points including Peterborough. At Brockville a full-scale installation is being planned as the only treatment preceding chlorination.

Contact Basins

Suspended-solids contact basins of a number of different manufacturers have been installed in many newly constructed plants. The operation of these devices appears to be quite satisfactory on the whole, the greatest difficulties

apparently arising from the poorer flocculation that occurs at low water temperatures.

At Brandon, Man., the capacity is reduced to about one-half of normal rating during the period of low temperature, and clay is used to hold the floc down. At the Moose Jaw-Regina, Sask., plant plankton organisms are not removed, and carry over to the filters. At Port Credit, Ont., the operation has been upset as a result of fluctuations in flow.

Color Removal

Treatment for the removal of color is required at seventeen plants reporting. In some places the color is a seasonal problem, but in most it is continuous. The highest values for color were reported at Edmonton, Alta. (360), followed by Iroquois Falls, Ont., and Malartic, Que. (250). In most cases the color arises from swamps and muskeg areas on the watersheds.

Color removal is effected by alum coagulation at a low pH (5.0–6.0), which is obtained by using a large dose of alum. Alum dosages are thus frequently proportioned against raw-water alkalinity rather than against color intensity. Because filtered water at this low pH is corrosive, adjustment of the pH to a higher value is required, and this is effected by the addition of lime or soda ash.

It is noteworthy that the only interference with color removal which was mentioned was at Ottawa, Ont., where it is attributed to the intermittent occurrence from natural sources of small amounts of fluoride in the river water.

Filtration

Rapid gravity filters are the ones most generally used for filtration, fol-

lowed by pressure filters. It is worth noting that there are still in use in Canada a number of slow sand filters (five in Ontario, eight in Quebec, one in Nova Scotia) and three drifting sand plants (Brampton, Rockland and Toronto, Ont.).

The Toronto plants are the only ones which are well documented. The slow sand filters operating at 0.03–0.05 gpm per square foot handle raw water whose turbidity ranges from 1 to 800, without the use of coagulant. They are scraped every 2 weeks and raked once in the interval. They have operated without major repairs since their installation in 1911. The drifting sand plant, installed in 1918, operates at 2.5 gpm per square foot, using the same raw water and alum at doses from zero to 35.8 ppm. In both cases the quality of the filtrate is excellent.

The details of filter design will not be discussed, except to note the increasing importance which is attached to the use of surface wash in keeping the filters clean. In two large plants at Toronto and Hamilton, where surface wash is not installed at present, new filters being constructed will include this feature.

The maximum length of filter run is usually set at 24 hr; a few plants run longer, and some terminate runs at 18 hr. Since wash water is usually not an expensive item in filtration plants, the use of more frequent washes to keep the filters clean is economical and efficient. The length of run, if not limited by the maximum mentioned, is usually determined by the loss of head. At Ottawa, Ont., the appearance of color in the filtered water terminates the run.

Difficulties experienced in filter operation do not appear to be serious. Only one plant mentioned the presence

of mudballs, and one plant reported difficulty with air binding during periods of high water temperature. The interference of algae on filter runs is sometimes combated by using a very short wash or bumping of filters between regular washes, to break up the mat of algae on the sand surface. This practice, which was used at Hamilton for a number of years, was discontinued because of the deterioration in quality of the filtered water following bumping.

Disinfection

Chlorine is used almost exclusively for disinfection; only one plant in Canada uses ozone. Chlorination is so inextricably involved with the control of taste and odor that it is difficult to separate the two. Free chlorine is most generally used, as distinguished from the intentional use of combined chlorine, but it is by no means certain that the residual obtained is always free chlorine.

Combined-chlorine residuals are maintained at four larger municipalities (Brantford and Hamilton, Ont., Victoria, B.C., and Winnipeg, Man.) and several smaller places. The reasons for choosing this combined residual are the more stable residual which persists throughout the distribution system, the avoiding of chlorinous odors in the presence of organic matter, and the avoiding of chlorophenolic odors.

The measurement of chlorine residual is usually done by the orthotolidine method, using bottled standards or permanent glass standards. The increasing application of residual recorders is of considerable interest. There are now twenty units in operation: nine in Ontario, one in Saskatchewan, one in Alberta, one in British Columbia, five in Quebec, and three in New Brunswick.

Tastes and Odors

Taste and odor difficulties are widespread in water purification. More than 50 per cent of the plants which reported in this survey employed some treatment specifically for taste and odor improvement. The objectionable taste and odors arise from algae, decomposing vegetable matter in swamps and muskeg, and phenolic substances in industrial wastes. Taste and odor from the first two sources frequently occur in the same water supply, and are usually increased in intensity by chlorination at low dosages. In the third case the objectionable taste and odor arises directly from chlorination.

Five municipalities use chlorine-ammonia treatment instead of chlorination to avoid the production of taste and odor. This treatment is effective since it reduces the chemical reactivity of chlorine and thus prevents the reaction of chlorine with organic substances. At Edmonton and Calgary, Alta., and Victoria, B.C., chlorine-ammonia treatment is used continuously to prevent the development of chlorinous odors when algae are present. At Welland and Hamilton, Ont., chlorine-ammonia treatment is used to avoid the development of chlorophenolic odors. Since the occurrence of phenolic substances is intermittent and unpredictable, this treatment must be used continuously. At Welland chlorine dioxide treatment is available if needed for abnormally high phenolic concentrations, but at Hamilton the chlorine-ammonia treatment has been entirely satisfactory in handling any concentrations of phenol which have occurred to date.

High dosages of chlorine may frequently be effective in controlling taste and odor by the chemical destruc-

tion of organic matter by a free chlorine residual. This involves the use of quite high chlorine dosages to maintain high residuals, and when the operation is well controlled the results are highly satisfactory.

At Windsor, Ont., where algae and industrial wastes combine to make a difficult problem the maintenance of high free chlorine residuals, and careful control of the treatment has been extremely effective. Tests are made every hour for taste and odor and chlorine demand. When taste and odor are encountered tests are made at several points at more frequent intervals, and free chlorine residuals are maintained at not less than 0.6 ppm.

Superchlorination as developed by the late N. J. Howard is used at the two large Toronto plants for the control of taste and odor from phenolic wastes and is very effective.

At Brantford, Ont., the extremely polluted Grand River water is treated by heavy chlorination to give a free chlorine residual of 2.5-4.5 ppm after 1 hr contact, then dechlorinated by sulfur dioxide, and finally given a chlorine-ammonia treatment to carry a residual through the distribution system. The details of this highly specialized problem have been published in several articles (3-6).

Less extreme chlorine treatment has been reported by some municipalities as giving satisfactory results under their circumstances. At Ottawa, Ont., with a soft, colored water, no other taste and odor treatment has been required since prechlorination has been used. At Chatham, Ont., fairly good control of taste and odor from algae results from prechlorination, and at Shawinigan Falls, Que., high prechlorine treatment for algae odors is effective.

Prechlorination has another valuable effect in taste and odor control by retarding the decomposition of sludge in settling basins and thus preventing the development of putrefactive odors.

Chlorine dioxide is effective, convenient, and economical for the destruction of chlorophenolic odors, and facilities for its use are provided in several plants, all in southern Ontario (Scarborough, New Toronto, Port Credit, Toronto Township, Welland, Thorold, Dundas, and Perth). In some, the treatment is used only when it is required, with the result that some odorous water is delivered to the distribution system before the treatment can be started. In others the treatment is maintained continuously at a low rate to take care of the erratic occurrence of phenolic contamination. At Perth, Ont., the use of chlorine dioxide for algae odors is reported as satisfactory, and at Dundas chlorine dioxide prevents the development of chlorinous odors on treating a highly organic water.

Activated carbon does not appear to be widely used for taste and odor control. At the Regina plant it is used with prechlorination with good results for odors from algae and decaying vegetable matter. At Edmonton, Alta., dosages of carbon up to 40 ppm are required for effective taste and odor removal during the spring breakup. Dosages up to 12.5 ppm were ineffective. The use of carbon slurry is being considered. At Wainwright, Alta., heavy prechlorination of a highly organic water produced chlorinous odors which could be removed by feeding a large dose of carbon directly to the filters. A continuous dose of 3 ppm activated carbon is also used the year round. At Dundas, Ont., carbon is used when abnormally high odors are not removed by other treatment.

Hydrogen sulfide odors in well waters are generally susceptible to removal by aeration as at Virden, Man., and London, Ont. At Watford, Ont., high chlorination following aeration is necessary.

Softening

There are nine softening plants in Canada using the lime or lime-soda process, of which only four (Edmonton and Wainwright, Alta., Brandon and Boesevain, Man.) contributed to this survey. They soften raw waters with hardness varying from 100–600 ppm down to 75–125 ppm; recarbonation to stabilize the softened water is practiced in all. At Brandon, Man., polyphosphate at 1 ppm is also applied to stabilize the water in the distribution system.

In metropolitan Toronto, there are six small plants softening well waters by resin ion exchanger. The hardness is reduced from 300–500 ppm to 125 ppm. In four plants aeration and filtration is provided for iron removal; in the other two the iron is removed by the ion exchanger.

There are some nine or ten other municipalities in Canada which remove iron from well water supplies by aeration and filtration.

Conclusion

Water treatment in some 200 plants in Canada which employ more extensive treatment than simple chlorination appear to be effectively and efficiently conducted. A wide variety of water conditions exist, and almost all practicable water treatment processes are represented in the water works which have been surveyed. Where treatment in its present form is not adequate, improved processes are being studied, planned, or installed. It is noted that in some of the smaller works the opera-

tors show interest and enterprise in investigating the possibility of finding solutions to their problems.

One question asked in the survey—"Do you have any problems that are not handled by known methods of water treatment?"—brought a practically unanimous answer in the negative.

The authors are much indebted to the many water works engineers throughout Canada who kindly contributed the data for this paper.

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Acceptability of Membrane Filter Procedure

The Executive Committee of the AWWA Board of Directors, on Nov. 7, 1957, adopted the following resolution:

Whereas the current (tenth) edition (1955) of *Standard Methods for the Examination of Water, Sewage, and Industrial Wastes* includes the membrane filter procedure as a tentative method for the determination of the presence of members of the coliform group, and

Whereas the US Public Health Service has, by official action, taken on Mar. 1, 1957, accepted the membrane filter as an alternate to the completed test for members of the coliform group,

Therefore, be it resolved that the American Water Works Association accepts the membrane filter procedure as an alternate to the completed test when the following conditions have been met:

a. The administrator of the laboratory concerned has satisfied himself by comparison tests that the membrane filter procedure produces results which are essentially equal to the completed test, and

b. The state sanitary engineering laboratory approves the application of the membrane filter procedure to the public water supplies under its jurisdiction.

A Statistical Analysis of Water Works Data for 1955

—Harris F. Seidel and E. Robert Baumann—

A contribution to the Journal by Harris F. Seidel, Supt., Water & Sewage Treatment, Ames, Iowa, and E. Robert Baumann, Prof. of Civil (San.) Eng., Iowa State College, Ames, Iowa.

IN May 1957 the JOURNAL published "A Survey of Operating Data for Water Works in 1955" (1)—perhaps one of the most formidable and impressive masses of numbers published recently by a nongovernmental organization. The survey comprised a wealth of information on physical systems, water use, rates, and finances of 497 United States water utilities serving populations of 10,000 or more. The combined population served by these utilities was just over 70,000,000—more than 60 per cent of the total population served by all water utilities.

The data present at least two broad areas of interest which are open to a statistical approach. The first involves the presence (or absence) of general trends, as shown by averages, ranges, and frequencies, which may answer such questions as: Is a specific cost element affected by size of city? Do high rates affect water use? Are rates keeping up with rising costs? What can be learned from a comparison of the current survey with the surveys of 1950 (2) and 1945 (3)?

The second area of interest is the possibility of determining norms or typical data for various aspects of water works operation so that the management of a particular utility can judge how it compares with other utilities operating under similar conditions.

Statistical Terminology

The statistical methods used in this study were relatively simple, and the terminology is correspondingly simple. An analysis of rates charged for the first 1,000 cu ft of water used per month will serve as an example (Fig. 1).

This item was reported by 480 cities; the charges ranged from \$0.68 to \$7.50. Summing all charges and dividing this total by the number of cities reporting yielded the arithmetical average or mean value (black triangle) of \$2.75. All mean values are unweighted; no extra weight was given data from the larger cities, as the main object of this analysis was to arrive at values most representative of the largest number of water utilities.

The mean value, while familiar to all, may be appreciably distorted by a few unusually high or low values. Consequently, the median value (white triangle) is generally a better indication of the most common or typical value in a group of data; it is the midpoint of the series, with as many individual values above as below it in the range of the series.*

* In the discussion which follows, averages of mean and median values are sometimes used, when such averages were considered to be more typical than either mean or median values.

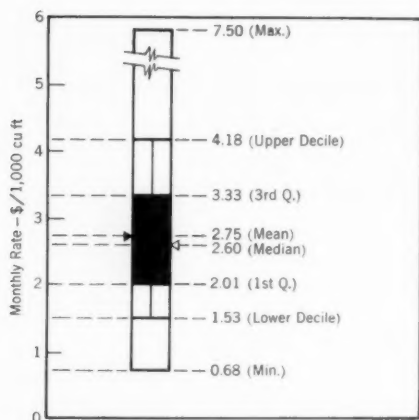


Fig. 1. Monthly Rates for First 1,000 cu ft
These data are based on returns from 480 cities.

The *quartiles* provide further information on grouping. A quarter of the values lie below the first quartile value and a quarter above the third quartile. In these terms, half the rates in Fig. 1 lie between \$2.01 (1st Q.) and \$3.33 (3rd Q.), which is less than one-fifth the full range (\$0.68-\$7.50) for the group. The second quartile value is, of course, the median.

The *decile* values merely carry this bracketing one step further in an effort to discount the undue influence of unusually low or high values on the plotted range. In Fig. 1, only one-tenth of the data lie below \$1.53 (lower decile) or above \$4.18 (upper decile); thus, 80 per cent of the data lie within these limits, which comprise less than 40 per cent of the overall range of the data.

With this information plotted in a summary bar graph such as Fig. 1, the general pattern of 1,000-cu-ft rates is apparent at a glance, as well as the quartile in which a specific rate falls, or whether it happens to be in the lower or higher tenth of all those reporting.

A statistical pattern may also be plotted in the form of a frequency dis-

tribution. The vertical bars in Fig. 2, for example, indicate the number of cities that reported per capita production values falling within the steps shown by the bottom scale. It is noteworthy that, despite mean and median production values of 137 and 122 gpcd, respectively, the heaviest concentration of data still falls around the 100-gpcd value. The summary bar graph and frequency distribution can be used together, as shown.

Limitations

It is well said that statistics can be used to prove almost anything. Consequently, part of the job of presentation is to define properly the limits and characteristics of the data.

For example, the mean monthly charge per 1,000 cu ft for 480 cities was found to be \$2.75. A second

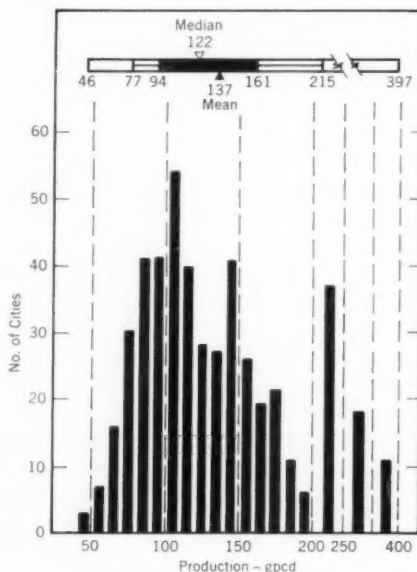


Fig. 2. Per Capita Production

This frequency distribution is based on returns from 477 cities. Per capita figures refer to total (retail plus wholesale) population served.

look, however, indicates that the mean rate for publicly owned utilities is \$2.62, compared to \$3.70 for those privately owned; lower production volume, a heavy tax load, and the profit motive are jointly responsible for the higher rate schedules of private utilities.

about \$2 for the largest cities. When arranged in groups according to volume of water produced, the rate variation from smallest to largest producers is even greater.

Another important factor influencing water rates is the type of treatment;

Concordance of Survey and Analysis Tables

Survey (May 1957 Journal)	Subject	Analysis (Dec. 1957 Journal)	Survey (May 1957 Journal)	Subject	Analysis (Dec. 1957 Journal)
Table 1, Column		Table (T) or Figure (F) No.	Table 3, Column		Table (T) or Figure (F) No.
1	Population & volume groups	T1	14-17	Monthly rates	T20, F1, F12
16	Distribution storage	T9	—	Effect of rates on use	F5
17-20	Distribution pressure	T11	—	Rates & treatment type	F6
21, 22	Distribution temperature	T10	18	Hydrant charge	T18
			20	Billing written off	T19
Table 2, Column			Table 4, Column		
6	Distribution mains	T8	2-4	Sources of revenue	T22, T31, F8, F9
8	Valves	T9	11	Per capita revenue	T21, F7
10	Hydrants	T9	13, 14	Operation & maintenance	T23
15	Unaccounted-for water	T5	18	Per capita expense	T24
16	Per capita production	T2, T3, F2, F3	20-24	Funds for capital additions	T28
17	Per capita distribution	T4	25, 26	Book value	T29, T30
Table 3, Column			27-29	Reserves & debt	T29, F11
2	Employees	T12	31	Earnings	T25
3-7	Customers	T13, T14	32-39	Disposition of earnings	T26, T27, T31, F10
—	Customer water use	T6, T7, F4		Comparisons	
8, 9	Services metered	T15	—	Public & private	T32, T33, F12-F14
10	Billing period	T16	—	1945-55 data	T33, F13, F14
11, 13	Minimum charge & allowance	T17			

Are there other factors which affect rates? Further analysis by size of city indicates that the mean monthly rate per 1,000 cu ft for publicly owned utilities varies from roughly \$3 in the 10,000-25,000 population bracket to

utilities needing only to chlorinate and distribute a well supply can operate at a considerable advantage in costs and rates over those required to treat a surface supply. Rates can also be shown to vary with geographic area.

It is apparent that a completely fair comparison of water rates should consider ownership, population, volume, treatment, and location (not to mention source, climate, and other factors), but this makes the comparison too complicated to be of any practical value. The major factors affecting any item must be taken into account, however, if a statistical analysis of the data is to have meaning.

The second important limitation in statistical work is the "sample" itself. The mean monthly rate per 1,000 cu ft for publicly owned utilities was stated to be \$2.62. This, of course, was the mean for those reporting. It is scarcely possible, nor is it necessary, to obtain data from every water utility. Instead, statistical work relies on a partial sample which is presumed to be representative. Thus, statistical results can only be as good as the original sample and the accuracy of reporting—a problem which is not eased by the wildly varying interpretations placed on such terms as "free service," "depreciation," and "earnings." Comparisons of 1955 data with results from the two earlier AWWA surveys are valid only to the extent that the sampling was equally good in all and that terms such as "earnings" were used in like context.

Despite the limitations described, results obtained from each succeeding survey have been increasingly authoritative and of growing value to the water works field. Approximately two-thirds of the cities included in the 1955 survey had also responded to one or both of the previous two.

Scope of Study

The discussion of the statistical material follows generally the organization of the survey (see table on p. 1533). The categories analyzed include: pro-

duction and distribution; physical system; billing and rates; revenue; expense; comparison of privately and publicly owned utilities; and comparison with statistical analyses of previous surveys (4, 5).

For purposes of this analysis, the cities were divided into the following population groups:

Population Group	Population Served at Retail 1,000's
1	10-25
2	25-50
3	50-100
4	100-250
5	250-500
6	over 500

For many items, a grouping by volume of production yielded more definite trends than an analysis by population groups. For volume groups, the following classification was used:

Volume Group	Production mgd
1	under 2
2	2-4
3	4-6
4	6-10
5	10-20
6	20-50
7	over 50

These volume groups do not duplicate those used in the analysis of the 1950 survey (4) but are in the more familiar terms of mean daily production. Generally speaking, considerable variation in size of city occurs within a volume group, as indicated in Table 1. Throughout the tables and illustrations, the population and volume groups are referred to by the above numbers.

Production and rates also vary with geographic location; the regional groupings used, as in past surveys, are as follows:

1. *New England*—Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont

2. *Middle Atlantic*—Delaware, Maryland, New Jersey, New York, Pennsylvania; also Washington, D.C.

3. *North East Central*—Illinois, Indiana, Michigan, Ohio, West Virginia

4. *North West Central*—Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Wisconsin

5. *South*—Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia

No attempt was made to summarize the volume of water produced from ground or surface sources and treated by different methods, or the population served by the various combinations of source and treatment. This information was recently accumulated in great detail by the US Public Health Service; a summary by Ralph Porges (6) appears in this issue (p. 1567).

Production

Per capita water use has long been a favorite item for comparison. In

TABLE 1
Retail Population of Cities in 1955 Survey, by Volume Groups

Volume Group	No. of Cities	Population—1,000's					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
1	98	10	30	16	13	15	18
2	128	11	60	25	18	23	30
3	64	13	75	37	26	34	50
4	63	21	155	60	44	59	71
5	49	30	210	110	80	104	148
6	54	55	555	223	142	195	283
7	37	165	7,650	1,030	500	585	920
1-7	493	10	7,650	135	20	35	93
1-7 (1950)	386	10	4,138	121	20	38	95

6. *Mountain*—Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming

7. *Pacific Coast*—California, Hawaii, Oregon, Washington.

The type of treatment has a definite bearing on operating costs, and thus on rates. The cities surveyed were classified by treatment type in three groups:

Minor—all cities not falling in another group (majority providing chlorination only)

Filtration—all cities reporting filtration, but not softening

Softening—all cities reporting softening, with or without filtration or other treatment.

the 1955 survey, per capita production was determined by dividing mean daily production by total (retail and wholesale) population served. For the 477 cities reporting these data, mean and median values were 137 and 122 gpcd, respectively, although the range of greatest frequency was 80-120 gpcd (Fig. 2).

Size of city (Table 2), above 10,000 population at least, was found to have little effect on per capita production. The only exception was the group of cities over 1,000,000 in population (part of Population Group 6), for which mean and median production values were in the range of 175 gpcd.

TABLE 2
Production, by Population Groups

Pop. Group	No. of Cities	Production— <i>gpcd</i> *					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
1	178	53	333	132	91	114	161
2	111	47	397	143	95	130	177
3	73	46	392	123	89	111	144
4	65	46	392	147	100	131	168
5	20	94	213	142	120	142	157
6	30	78	234	146	112	146	176
1-6	477	46	397	137	94	122	161
1-6 (1950)	387	51	446	138	95	122	160
1-6 (1945)	398	34	546	125	85	110	145

* Per capita figures based on total (retail plus wholesale) population served.

TABLE 3
Production, by Geographic Regions

Region	No. of Cities	Production— <i>gpcd</i> *					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
New England	38	59	263	123	92	115	147
Middle Atlantic	73	56	380	139	94	122	173
South	106	46	275	109	84	103	124
N. East Central	84	46	286	130	92	126	152
N. West Central	100	51	295	127	93	117	157
Mountain	17	97	397	220	149	202	248
Pacific Coast	59	85	356	193	143	179	228
US	477	46	397	137	94	122	161

* Per capita figures based on total (retail plus wholesale) population served.

TABLE 4
Distribution, by Population Groups

Pop. Group	No. of Cities	Distribution— <i>gpcd</i> *					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
1	136	51	326	118	80	100	139
2	93	37	397	123	77	108	149
3	65	39	392	106	78	92	119
4	54	46	331	124	79	112	145
5	16	87	181	125	102	122	140
6	27	63	230	127	93	122	156
1-6	391	37	397	119	81	104	142

* Per capita figures based on total (retail plus wholesale) population served.

When analyzed by volume groups (Fig. 3), a definite trend was evident. As the total production increased, per capita production also increased fairly consistently, from about 90 gpcd for Volume Group 1 to 160 gpcd for Volume Group 7. This suggests that, as in other industries, the larger water utilities are able to take advantage of

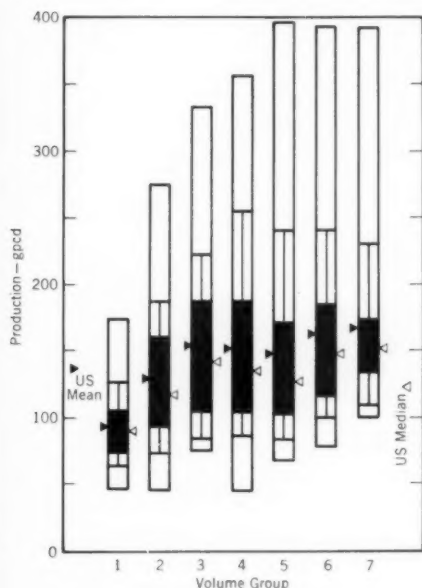


Fig. 3. Per Capita Production, by Volume Groups

The larger volume groups show generally higher production figures per capita (retail plus wholesale population served).

lower unit costs to provide water at lower rates and thereby stimulate sales.

Production also varied with geographic region (Table 3). As in the two previous surveys, per capita water use was considerably higher in Pacific and Mountain states than in other areas. A study of only those cities reporting in both the 1950 and 1955 surveys indicated decreases of 7 and 8

per cent in Pacific and Mountain regions, respectively; increases of 4 per cent in New England and North West Central regions; and negligible changes in other areas over this 5-year period. Possibly regional climatic conditions played as important a part in these variations as any other single factor.

It is of particular interest to note that per capita water use did not change significantly from 1950 to 1955. This is in contrast to a 10 per cent increase during the 1945-50 period. It should

TABLE 5

Frequency Data on Percentage of Production Sold and Unaccounted for *

Production Sold per cent	No. of Cities	Unaccounted for per cent	No. of Cities
100.0	22	0.0	90
95.0-99.9	49	0.1- 4.9	40
90.0-94.9	61	5.0- 9.9	52
85.0-89.9	78	10.0-14.9	72
80.0-84.9	70	15.0-19.9	55
75.0-79.9	51	20.0-24.9	33
70.0-74.9	33	25.0-29.9	17
60.0-69.9	24	30.0-39.9	13
under 60.0	13	40.0 or more	7
Total	401	Total	379

* "Production sold" percentages are based on sales reported (Survey Table 2, Col. 12); "unaccounted for" percentages are based on total distribution (sales plus free) reported (Survey Table 2, Col. 14).

be pointed out, however, that the 1950 data did not include population served at wholesale in a number of cases, which may have affected the per capita figures, but not by more than 1-2 gpcd.

Distribution

Many cities reported the volume of water sold and an amount designated as "free service." The sum of sales and free service was tabulated as "total distribution." Approximately 20 cities reported sales as matching production exactly, and about 70 more indicated

that sales plus free service, or total distribution, precisely equaled production. This is an admirable achievement, if accurate, but the statistical results involving such data are suspect. Mean and median values for total dis-

tribution were found (Table 4) to be 119 and 104 gpcd, respectively, subject to the reservations noted.

A frequency distribution (Table 5) of data on percentage of production sold and percentage unaccounted for indi-

TABLE 6
Residential Water Use, by Volume Groups

Volume Group	No. of Cities	Annual Use per Residential Service—1,000 gal					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
Publicly Owned Utilities							
1	15	29	101	53	46	50	55
2	20	31	123	64	48	60	70
3	11	38	129	75	55	62	97
4	14	41	151	82	57	80	97
5	8	62	117	81	(65)	77	(92)
6	6	74	103	89	(82)	90	(97)
7	12	62	149	94	72	97	107
1-7	86	29	151	74	53	68	96
Privately Owned Utilities							
1	7	42	58	49		48	
2	8	34	96	55		45	
3-7	10	49	118	71		70	
1-7	25	34	118	60	45	52	75

TABLE 7
Customer Water Use

Customer Class	No. of Cities	Annual Use per Service—1,000 gal					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
Publicly Owned Utilities							
Residential	86	29	151	74	53	68	96
Commercial	68	120	880	390	250	350	450
Industrial	66	400	54,500	10,000	4,100	8,000	13,300
Privately Owned Utilities							
Residential	25	34	118	60	45	52	75
Commercial	23	120	640	300	170	280	370
Industrial	21	400	54,000	7,000	2,100	3,600	6,300

cated the ranges of most common experience to have been 80-95 per cent sold and 5-20 per cent unaccounted for (disregarding those cities reporting 100 per cent distribution). Highest frequency of occurrence was noted for values of 86 per cent and 12 per cent, respectively; this was not significantly better or worse than in the two previous surveys.

The survey tabulation also included data on loss per mile of main, assuming all undistributed water to be lost via distribution mains. In those terms, the most representative values were in the range of 4,000-8,000-gpd loss per mile.

Water Use

After the original survey data had been received and tabulated, a second request was sent to 150 utilities for more detailed information on water sales. From this mailing more than 125 replies were received, most of them quite complete.

From the breakdown of water sales into residential, commercial, and industrial categories, and from data previously furnished (Survey Table 3) on the number of services in each class, mean annual water use per service was calculated.

Mean residential water use (Table 6) was found to vary from about 50,000 gal per service per year (approximately 140 gpd) for the smaller utilities to 100,000 gal per year (roughly 275 gpd) for cities in the largest volume group. For privately owned utilities, a parallel trend was observed, but with the water use per service generally 10-20 per cent lower than for publicly owned utilities.

For commercial and industrial use, similar trends were lacking. The variations in mean use per service were greater, however, particularly for the

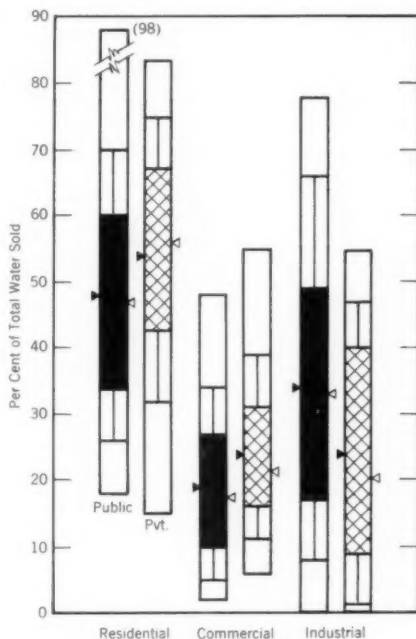


Fig. 4. Breakdown of Sales by Service Classes

"Total water sold" refers to total sales to residential, commercial, and industrial accounts (municipal sales and free service excluded). The left-hand bar of each pair shows data for publicly owned utilities, the right-hand for privately owned.

industrial class. In very general terms, commercial use was reported most commonly to be in the range of 0.25-0.5 mil gal per service per year, while industrial use ranged most frequently from 3 to 12 mil gal. For privately owned utilities, commercial and industrial use per service was roughly 20 per cent and 35 per cent less, respectively, than for publicly owned utilities. Table 7 summarizes water use data for all three service classes.

Analysis of the sales breakdown itself, in terms of total volume for these three classes only (Fig. 4), was also

productive. For publicly owned utilities, commercial sales increased (from 17 to 25 per cent) and industrial sales decreased mildly (from 35 to 30 per cent) in importance from the smallest to the largest population group. Resi-

dential sales accounted for half or slightly more than half of total sales in cities of 50,000-250,000 population, and less than half in cities smaller and larger than this.

For privately owned utilities, the im-

TABLE 8
Distribution Main Mileage, by Population Groups

Pop. Group	No. of Cities	Miles of Main per 1,000 Retail Pop.					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
1	147	0.8	5.3	2.9	2.3	2.8	3.5
2	104	0.9	4.7	2.6	2.2	2.7	2.9
3	70	0.7	4.9	2.4	1.8	2.4	2.8
4	57	0.9	4.6	2.4	2.0	2.3	2.6
5	20	1.1	3.1	2.1	1.6	2.1	2.6
6	25	1.2	3.2	2.0	1.5	1.9	2.3
1-6*	423	0.7	5.3	2.6	2.0	2.5	3.0
1-6 (1950)†	386	0.5	5.9	2.4	1.9	2.3	2.7
1-6 (1945)*	418	0.2	8.4	2.7	2.0	2.5	3.1

* Based on actual mileage of all sizes of mains.

† Based on miles of 8-in. equivalent main.

TABLE 9
Frequency Data on Valves, Hydrants, and Storage

Valves		Hydrants		Distribution Storage		
Per Mile of Main	No. of Cities	Per Mile of Main	No. of Cities	Days*	No. of Cities	
					Publicly Owned	Privately Owned
1.6- 3.9	6	1.4- 2.9	6	0.0- 0.2	18	4
4.0- 5.9	14	3.0- 3.9	19	0.2- 0.4	57	15
6.0- 7.9	31	4.0- 4.9	40	0.5- 0.7	66	11
8.0- 9.9	50	5.0- 5.9	66	0.8- 1.0	67	6
10.0-11.9	72	6.0- 6.9	74	1.1- 1.3	34	1
12.0-13.9	51	7.0- 7.9	61	1.4- 1.6	45	2
14.0-15.9	38	8.0- 8.9	55	1.7- 1.9	20	2
16.0-17.9	27	9.0- 9.9	41	2.0- 2.9	40	4
18.0-19.9	18	10.0-10.9	27	3.0- 3.9	13	2
20.0-21.9	12	11.0-11.9	11	4.0- 4.9	10	
22.0-25.9	12	12.0-12.9	9	5.0-10.1	14	
26.0-32.2	9	13.0-18.5	11			
					384	47
13.0†	340	7.4†	420	1.4†	431	
12.0‡	340	7.2‡	420	0.9‡	431	

* Average daily production.

† Mean.

‡ Median.

portance of residential sales increased sharply (from 52 per cent for the smallest companies to 68 for the largest), while both commercial and industrial sales declined, in several cases to negligible amounts. The qualification must be added that these statistical results depend entirely on how the utilities reporting chose to define the three service classes.

Information on what is generally classed as public or municipal use was meager, because it was not specifically requested. A careful review of those cities reporting indicated that municipal use varied most generally from 2 to 10 per cent of sales; 5 per cent would be representative. A slight majority of the publicly owned utilities reporting charged for all such use; the rest charged for roughly half and wrote off the remainder as free service. For privately owned utilities, the amount of free service was negligible.

The effect of rates on water use has long been of interest, and the breakdown provided valuable information on this point. Residential use was found (Fig. 5) to vary from 50,000 to 100,000 gal per year, correlating very generally with a trend in monthly water rates from \$5 to \$1 per 1,000 cu ft.

A similar study of the interrelationship of rates and total production yielded an almost identical pattern, with the water use values ranging from 100 gpcd (at the \$5 rate) to 180-200 gpcd at the \$1 rate.

There can be little argument about the basic influence of the cost of any product upon its use. Yet, after considerable statistical study, the authors remain skeptical that a rate adjustment has the prompt, proportionate effect on water use which the above relationships suggest. The authors feel that most rate adjustments are moderate enough

and that habits of water use are sufficiently stable to consign the rate factor to a distinctly minor role as an influence on fluctuations in water use.

Distribution System

Distribution main mileage (4-in. mains and larger) was found (Table 8) to vary generally from almost 3 miles per 1,000 population for the smallest

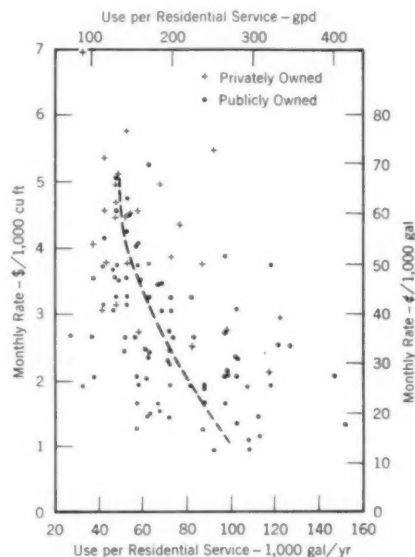


Fig. 5. Effect of Rates on Residential Use

Lower rates for first 1,000 cu ft appear to correlate with increased use.

cities surveyed to about 2 miles for the largest cities. No significant change since 1945 was apparent.

The number of hydrants per mile of main was found (Table 9) to be most commonly 6 or 7,* while the number of

* This was 10 per cent above the 1945 figure, perhaps because the 1945 returns were less careful to distinguish between transmission and distribution mains in reporting mileage.

TABLE 10
Distribution System Water Temperatures

Region and Source	No. of Cities	Water Temperature—°F					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
<i>New England</i>							
Surface							
Jan.	28	33	52	39	35	39	40
Jul.	28	50	79	67	64	70	79
Ground							
Jan.	2	52	56	54			
Jul.	2	52	62	57			
<i>Middle Atlantic</i>							
Surface							
Jan.	37	33	57	38	35	38	40
Jul.	37	55	82	70	65	70	75
Ground							
Jan.	11	43	60	52	50	52	55
Jul.	13	50	75	60	55	60	65
<i>South</i>							
Surface							
Jan.	56	36	68	47	42	46	51
Jul.	57	45	87	79	76	80	84
Ground							
Jan.	30	50	80	68	62	70	75
Jul.	30	52	90	73	67	71	80
<i>N. East Central</i>							
Surface							
Jan.	41	32	45	37	34	36	40
Jul.	41	55	82	72	69	70	76
Ground							
Jan.	25	50	65	54	52	54	56
Jul.	25	52	68	58	55	56	60
<i>N. West Central</i>							
Surface							
Jan.	39	32	50	38	34	36	40
Jul.	39	48	90	73	63	75	80
Ground							
Jan.	44	34	65	53	50	54	56
Jul.	45	40	73	58	54	57	62
<i>Mountain</i>							
Surface							
Jan.	9	32	50	41	(35)	40	(48)
Jul.	9	54	67	59	(56)	58	(61)
Ground							
Jan.	2	65	71	68			
Jul.	2	71	84	78			
<i>Pacific Coast</i>							
Surface							
Jan.	19	35	61	46	39	46	52
Jul.	19	53	77	65	59	65	68
Ground							
Jan.	17	48	68	63	61	67	68
Jul.	18	51	75	66	64	68	69

TABLE 10—Distribution System Water Temperatures (contd.)

Region and Source	No. of Cities	Water Temperature—°F					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
US							
Surface							
Jan.	229	32	68	41.0	35	40	45
Jul.	230	45	90	71.8	65	72	78
Ground							
Jan.	131	34	80	58.1	52	56	65
Jul.	135	40	90	62.9	55	60	70
Surface & ground							
Jan.	360	32	80	47.2	38	45	55
Jul.	365	40	90	68.5	60	70	76
January & July							
Surface	459	32	90	56.5	40	55	71
Ground	266	34	90	60.5	54	58	68
US average	(725)	32	90	58.0	45	58	70

TABLE 11

Distribution System Pressures

Pressure psi	Business District		Residential District	
	Min.	Max.	Min.	Max.
	No. of Cities			
3-9			5	
10-19			14	
20-29	11		63	
30-39	29	1	115	1
40-49	91	12	124	13
50-59	101	44	82	48
60-69	89	96	31	77
70-79	58	79	10	63
80-89	35	62	5	49
90-99	19	54	1	45
100-109	11	47		51
110-119	4	21		19
120-129	3	21	1	38
130-139	1	6		13
140-149		12		12
150-159		3		12
160-169		4		8
170-179		2		4
180-250		3		13
61*, 85†	452	467		
42*, 93†			451	466

* Mean minimum. † Mean maximum.

valves (Table 9) was most frequently in the range of 10-12 per mile of main. No significant trend by size of city was apparent for either.

Storage in terms of average daily production was also reviewed. The intention was to include all storage actually available on the distribution system, whether ground or elevated, gravity or pumped, but to discount impounding storage used primarily as a supply source. The result was a rather broad spread, but without important variation by size of city. The range of greatest frequency was 0.5-1.5 days' production volume (Table 9).

Water Temperature

Average January and July distribution system water temperature data are summarized in Table 10. For surface supplies a difference of 30°F between these months (most frequent values: 40° for January and 70° for July) was typical, with variations as high as 45° and 50° reported. For ground supplies, the difference was most generally on the order of 5°F; most frequent values were 58° for January and 63° for July. For all supplies, seasons, and

sections of the country, the mean (and median) water temperature was 58°F.

Pressure

The survey form requested maximum and minimum pressures for both the business and the residential dis-

tricts of each distribution system. Frequency data (Table 11) indicate, in very general terms, that business district pressures ranged most typically from 60 to 85 psi, while those in residential districts were subject to greater variation, from roughly 40 to 90 psi.

TABLE 12
Employees, by Treatment Types

Ownership and Treatment Type	No. of Cities	No. of Employees per 1,000 Retail Pop.					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
Publicly owned							
Minor	71	0.29	2.93	0.84	0.57	0.69	1.10
Filtration	92	0.32	2.86	0.98	0.70	0.92	1.16
Softening	53	0.45	2.00	0.96	0.75	0.91	1.16
All	216	0.29	2.93	0.93	0.66	0.88	1.10
Privately owned	32	0.24	1.14	0.75	0.57	0.76	0.88
US	248	0.24	2.93	0.92	0.66	0.86	1.07
US (1950)	394	0.23	3.10	0.89	0.62	0.81	1.09

TABLE 13
Population per Residential Service

Pop. Group	No. of Cities	Retail Pop. per Residential Service					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
1	99	2.8	7.1	4.3	3.6	4.1	4.6
2	66	3.0	8.0	4.4	3.8	4.3	4.8
3	45	3.3	7.2	4.6	4.1	4.4	4.8
4	26	3.5	6.7	4.9	4.1	4.6	5.7
5	9	3.9	6.4	4.8	(4.1)	4.5	(5.3)
6	22	3.7	8.6	5.5	4.4	5.4	6.3
1-6	267	2.8	8.6	4.5	3.9	4.3	5.0

TABLE 14
Services per 1,000 Population, by Service Class

Service Class	No. of Cities	No. of Services per 1,000 Retail Pop.					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
Residential	267	115	360	230	200	230	255
Commercial	196	0	55	19	10	18	24
Industrial	196	0.0	9.3	1.9	0.6	1.4	2.6
Public	254	0.0	5.0	1.2	0.5	1.0	1.7

Employees

Analysis indicated that mean and median values for the number of full-time water department employees (Table 12) were very close to 0.9 per 1,000 population—an increase of 5 per cent in the 1950–55 period. The range of most common occurrence was 0.6–1.0 per 1,000 population.

Both treatment type and ownership were found to affect the number of employees reported; utilities providing filtration or softening required approximately 20 per cent more employees than those classified in the minor-treatment group. Privately owned utilities as a group reported only 5 employees for every 6 in publicly owned utilities.

Service Accounts

Dividing the retail population by the number of residential customers yielded data on the number of persons per residential service. In these terms, the most frequent range was 4–4.5 persons; and it was also found (Table 13) that the number of persons trended from just over 4 in the lowest population group to roughly 5.5 in the largest. Undoubtedly, the number and size of multiple dwellings in the larger cities constitute a major factor in this trend.

For the other service classes, the calculation was reversed, to find the number of customer accounts per 1,000 population. Analysis indicated close to 20 commercial and approximately 2 industrial and 1 municipal service per 1,000 population. Together with the 230 (mean and median) residential services per 1,000, this gives a total of approximately 250 accounts of all types per 1,000 population for the "average" water utility (Table 14)—however, this figure ranged from less than 200 to almost 400.

Metering

Commercial and industrial services were very nearly completely metered; this was not the case for residential or municipal accounts. The data available for these two service classes are summarized in Table 15. In regard to metering, as in the number of customer services, the difference between privately and publicly owned utilities was not significant.

Billing Periods

Meter reading and billing periods ranged from monthly to annual inter-

TABLE 15

Frequency Data on Residential and Public Services Metered

Per Cent Metered	No. of Cities	
	Residential Services	Public Services
0	13	38
1–10	13	2
11–89	14	36
90–99	25	5
100	376	186
<i>Total</i>	441	267

vals and often varied for different service classes within a utility. By far the majority of commercial and industrial services were read and billed monthly, while almost half the cities reported billing residential customers quarterly, and some even less frequently. Residential billing periods also varied with size of city (Table 16); in the smallest cities, 50 per cent were on a monthly basis, while in the largest population groups only 10–15 per cent were billed monthly and 50–60 per cent quarterly. Bimonthly residential billing also was more common in larger cities.

Penalties and Discounts

A total of 466 cities answered the questions on penalty or discount provisions. Only 45 of these cities indicated discounts to be in effect, ranging from 3 to 20 per cent of the bill, with 10 per cent the most common discount (30 cities). Of the 217 cities with penalty provisions for late payment—ranging from 1 to 20 per cent of the bill, or

fixed amounts up to \$2.50—104 charged 10 per cent. Billing was reported as net by 204 cities.

Minimum Charge and Allowance

The minimum monthly charge for residential service (Table 17) ranged most commonly from \$1.00 to \$1.50. The amount allowed on the minimum charge (Table 17) ranged most often between 300 and 500 cu ft. Only 32

TABLE 16
Residential Billing Periods

Pop. Group	No. of Cities	Percentage of Cities Billing:			
		Monthly	Bimonthly	Quarterly	Semiannually or Annually
1	170	50	4	39	7
2	114	39	14	42	5
3	68	31	13	51	5
4	57	38	9	48	5
5	20	15	15	60	10
6	30	11	25	52	12
1-6	459	39	10	44	7

TABLE 17
Monthly Minimum Charge and Allowance

Group	No. of Cities	Min.	Max.	Mean	1st Q.	Median	3rd Q.
Minimum Charge per Month—\$							
Public	421	0.00	3.50	1.20	0.80	1.15	1.50
Private	58	0.00	3.15	1.52	1.25	1.50	1.85
US	479	0.00	3.50	1.25	0.90	1.20	1.50
US (1950)	339	0.15	4.25	1.00	0.67	1.00	1.25
Allowance on Minimum Charge—cu ft							
Public	370*	35	3,333	430	275	400	525
Private	51†	100	890	360	267	400	400
US	421	35	3,333	420	267	400	500
US (1950)	316	33	2,500	480	300	400	600

* Exclusive of 29 cities with service charge (no allowance).

† Exclusive of 3 cities with service charge (no allowance).

TABLE 18
Frequency Data on Annual Hydrant Charges

Annual Charge per Hydrant \$	No. of Cities	
	Publicly Owned	Privately Owned
none	128	1
less than 10	9	1
10-29	46	15
30-49	40	10
50 or more	20	15½
<i>Total</i>	243	42

of 453 cities reported a service charge, under which no allowance was granted but which was in addition to actual use charges.

The difference between publicly and privately owned utilities was quite pronounced. The latter allowed about 10 per cent less water on the minimum bill while maintaining minimum charges at a level 33 per cent above that of publicly owned utilities.

Public Fire Service Charge

With respect to charges for public fire service, privately owned utilities were roughly one-third higher than publicly owned. The schedule of charges ranged most commonly from \$10 to \$50 a year per hydrant (Table 18).

Billing Written off

Of the 372 cities reporting on billing written off as uncollectible, the majority gave a figure of less than 0.1 per cent. The data are summarized in Table 19. No significant difference was found between publicly and privately owned utilities in this regard.

Rate Schedules

In considering rates and finances, the differences between publicly and pri-

vately owned utilities were so substantial that it was believed more practical to evaluate them separately from this point on. Further references to privately owned utilities will be reserved for a later section (p. 1561). Similarly, further comparisons with previous surveys will be withheld for the concluding section of the analysis (p. 1564).

In the data survey, rates were tabulated for 1,000, 10,000, 100,000, and 1,000,000 cu ft per month. Analysis by population groups indicated a decrease in rates with increasing size, from mean and median values of about \$2.90 per 1,000 cu ft for Group 1 to \$2.00 for Group 6. By volume groups (Table 20), a similar but stronger trend was apparent, the rate decreasing from about \$3.20 per 1,000 cu ft for Group 1 to about \$2.00 for Group 7.

For 10,000 cu ft per month, rates varied typically from \$21.50 for Volume Group 1 to \$16.50 for Volume Group 7. For 100,000 and 1,000,000 cu ft, typical charges were \$130 and \$1,030, respectively, with little variation by size or volume group.

Analysis by treatment types (Fig. 6) indicated that rates were lowest for those in the minor-treatment classification, as could be expected in view of their lower operating costs. Rates for

TABLE 19
Frequency Data on Billing Written off

Per Cent of Total Billing Written off	No. of Cities
none	126
less than 0.01	44
0.01-0.09	61
0.10-0.24	50
0.25-0.59	45
0.60-1.00	27
over 1.00	19
<i>Total</i>	372

TABLE 20
Rate Schedules of Publicly Owned Utilities,* by Volume Groups

Volume Group	No. of Cities	Monthly Rate—\$/1,000 cu ft					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
1	82	1.50	5.75	3.21	2.50	3.18	3.64
2	117	0.98	7.50	2.75	2.03	2.69	3.29
3	58	1.30	6.00	2.74	2.08	2.69	3.33
4	56	0.68	4.85	2.41	1.75	2.20	2.98
5	41	1.00	5.20	2.35	1.78	2.15	2.80
6	43	0.80	4.18	2.10	1.69	2.08	2.37
7	35	0.90	3.29	2.02	1.43	2.04	2.56
1-7	432	0.68	7.50	2.62	1.93	2.50	3.19
1-7 (1950)	334	0.60	5.41	2.23	1.50	2.15	2.75
1-7 (1945)	334	0.50	4.25	1.89	1.35	1.70	2.30
Monthly Rate—\$/10,000 cu ft							
1	82	8.00	42.50	22.40	17.40	20.80	27.35
2	116	4.33	40.15	19.15	13.90	19.60	22.70
3	58	8.75	43.60	19.70	15.20	18.90	22.80
4	56	6.13	44.50	17.70	12.20	15.80	21.65
5	41	6.85	34.00	17.30	13.20	16.25	20.00
6	43	7.80	29.60	16.85	13.35	17.00	20.25
7	35	6.60	30.25	16.80	10.90	16.35	21.25
1-7	431	4.33	44.50	19.00	13.50	18.45	22.75
1-7 (1950)	334	3.75	44.66	16.80	12.00	16.00	20.50
1-7 (1945)	335	3.00	32.81	14.10	10.00	13.50	17.50
Monthly Rate—\$/100,000 cu ft							
1	79	57.91	327.40	151	100	143	185
2	114	35.55	296.95	134	96	136	165
3	58	50.00	234.18	134	95	127	177
4	56	36.30	244.00	126	88	113	158
5	41	61.83	227.96	120	93	112	145
6	42	54.60	299.60	126	93	123	145
7	35	62.26	270.00	133	100	127	170
1-7	425	35.55	327.40	134	93	126	162
1-7 (1950)	334	26.75	375.00	117	82	106	139
1-7 (1945)	334	15.00	250.17	93	67	87	120
Monthly Rate—\$/1,000,000 cu ft							
1	66	363	3,207	1,180	760	970	1,530
2	98	161	2,382	1,110	680	1,060	1,490
3	52	245	2,253	1,080	750	970	1,210
4	52	258	2,221	1,020	650	990	1,210
5	40	321	1,637	960	700	930	1,150
6	41	409	1,800	960	750	940	1,090
7	34	517	2,700	1,090	730	1,000	1,250
1-7	383	161	3,207	1,060	720	1,010	1,270
1-7 (1950)	331	146	3,750	936	640	805	1,110
1-7 (1945)	329	93	2,500	786	520	700	1,000

* For privately owned utilities, see Table 33.

cities in the filtration class were generally 20 per cent higher throughout the rate steps; for softening, rates for the smaller quantities were essentially the same as for filtration, but as much as 20 per cent above filtration at the 1,000,000-cu ft step.

Total Revenue

The data survey requested information on revenue from each customer

ranged from less than \$4 to more than \$30. The range of greatest frequency (Fig. 7) was \$8-\$10 per capita. Trends by either population or volume (Table 21) were lacking. (It should be noted again that this and succeeding sections are concerned only with publicly owned utilities.)

As derived, this per capita figure is open to serious criticism because many utilities, particularly the larger ones,

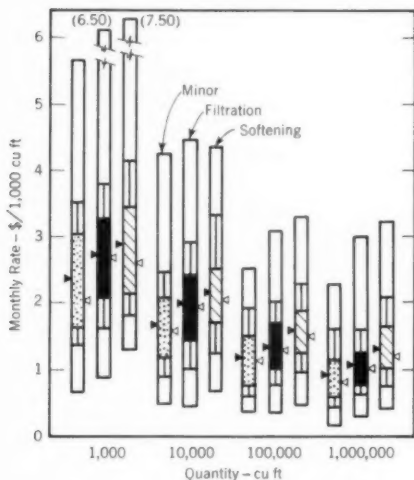


Fig. 6. Monthly Rates, by Treatment Types

Rates charged by publicly owned utilities with minor treatment, filtration, or softening are compared.

category, from public or municipal service, from public and private fire service, and from miscellaneous sources. This revenue total was then divided by retail population served to give a per capita revenue figure.

In these terms, mean and median values for annual per capita revenue for 376 cities were \$10.65 and \$10.05, respectively, although the returns

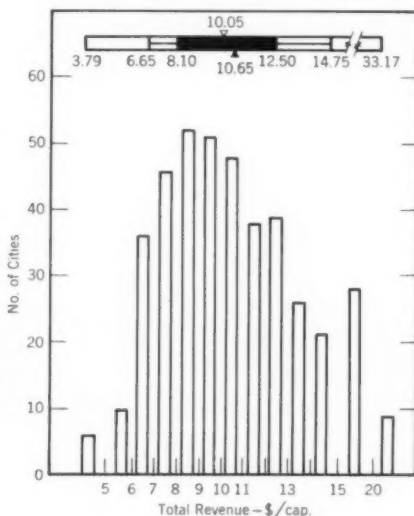


Fig. 7. Per Capita Revenue

These data, based on retail population served, are for 376 cities.

serve substantial wholesale demands not reflected in the population total. Also, the miscellaneous income reported, much of which is nonoperating, varies greatly and serves to distort further an analysis of water utility operations as such.

Calculation of total revenue per million gallons produced (Table 21) is somewhat more realistic. This figure

was found to vary from roughly \$290 for Volume Group 1 to about \$160 for Volume Group 7.

Water Sales Revenue

Analysis of revenue was carried one step further, to determine water sales revenue per million gallons. For this purpose, only income from residential, commercial, industrial, and municipal customers was totaled and then divided

by production volume. Water sales revenue, amounting to approximately 92 per cent of total revenue, was found to vary appreciably with population but was still more affected by volume (Table 21) ranging from about \$265 per million gallons for Volume Group 1 to \$145 for Volume Group 7.

Analysis by treatment types indicated that water sales revenue per million gallons for cities providing

TABLE 21
Revenue of Publicly Owned Utilities, by Volume Groups

Volume Group	No. of Cities	Total Revenue \$/cap.*		Total Revenue \$/mil gal†		Water Revenue \$/mil gal†	
		Mean	Median	Mean	Median	Mean	Median
1	67	9.98	9.70	300	278	279	255
2	98	10.64	10.25	235	230	220	210
3	53	11.54	10.75	222	212	201	195
4	48	10.92	10.80	207	185	189	172
5	36	10.92	9.85	212	200	195	183
6	40	10.66	10.10	189	187	176	176
7	34	9.48	8.80	160	152	148	146
1-7	376	10.65	10.05	228	214	210	196
1-7 (1950)	312	7.94	7.71	182	172		
1-7 (1945)	355	5.98	5.64	151	143		

* Per capita figures based on retail population served.

† Per million gallons produced.

TABLE 22
Major Sources of Revenue of Publicly Owned Utilities, by Population Groups*

Pop. Group	No. of Cities	Per Cent of Total Revenue					
		Resid. Svces.		Coml. Svces.		Ind. Svces.	
		Mean	Median	Mean	Median	Mean	Median
1	24	63	63	16	14	16	12
2	17	55	54	18	13	20	21
3	15	59	58	17	16	14	14
4	11	54	56	20	21	17	17
5	3	47	47	20	12	24	27
6	8	52	51	25	24	18	21
1-6	78	57	56	18	17	17	16

* Excluding Wisconsin.

softening was approximately \$20 higher than for those in the filtration class, while the filtration group, in turn, was collecting \$30 more than the revenue received by utilities in the minor-treatment class. The mean and median figures, respectively, were: for 130 utilities with minor treatment—\$178, \$170 per million gallons; for 158 with filtration—\$218, \$205; for 88 with softening—\$242, \$220.

Revenue per Service

From data on the number of services and on revenue from each service class, the mean annual revenue per service in each class was calculated for more than 100 utilities (Fig. 8). The results for residential services were particularly interesting. Mean annual revenue per service was \$25; the median value was \$23; the range of most common occurrence was \$18-\$24, with peak frequency at \$21. There was, however, no variation with population or volume, the broad implication being that such factors as the charge for water and per capita use balance each other.

It is also worth noting that, at 4 or more persons per service, the per capita annual revenue for residential service is slightly short of \$5, a far cry from the \$10+ per capita total revenue previously mentioned.

For commercial services, annual revenue ranged most commonly from \$60 to \$80 per account. The variation in annual revenue from industrial services was, of course, greater; the most common range was about \$300-\$800 per service, but for many cities, this figure was in thousands of dollars.

From these values and from data in the section on water use per service, it can be stated in highly generalized terms that residential customers were paying for their water at the rate of

approximately \$2.25 per 1,000 cu ft; commercial customers were paying about \$1.50 per 1,000 cu ft for the water used, and industrial customers about \$0.75. These values apply to publicly owned utilities only.

Sources of Revenue

A further detailed study (Fig. 9, Table 22) was made of 78 publicly

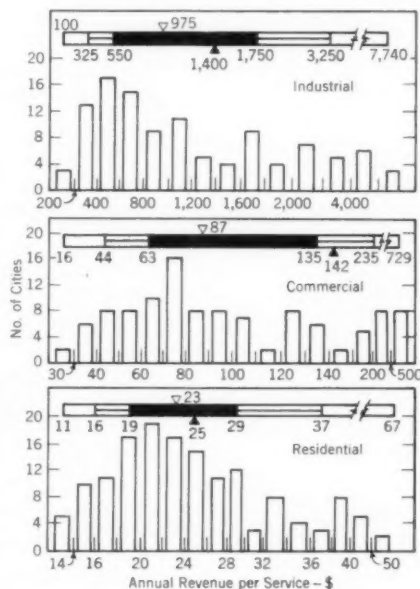


Fig. 8. Annual Revenue per Service

All data are for publicly owned utilities only; residential, 150 cities; commercial, 112 cities; industrial, 111 cities.

owned utilities providing a complete breakdown of revenue from each service class, and from fire service charges and miscellaneous sources as well. These cities were fairly representative in size and location (except that cities in Wisconsin were excluded; because of unique revenue and tax procedures,

the 20 cities reporting from that state are dealt with separately—see p. 1560).

The largest single source of revenue was from residential sales, ranging from over 60 per cent of total revenue for Population Group 1 to 50 per cent for Population Groups 5 and 6 (Table

residential customers provided 56 per cent of the total revenue, commercial customers 18 per cent, and industrial 17 per cent. (It may be pertinent to point out that industrial customers as a group were paying only one-sixth of the bill while consuming one-third of

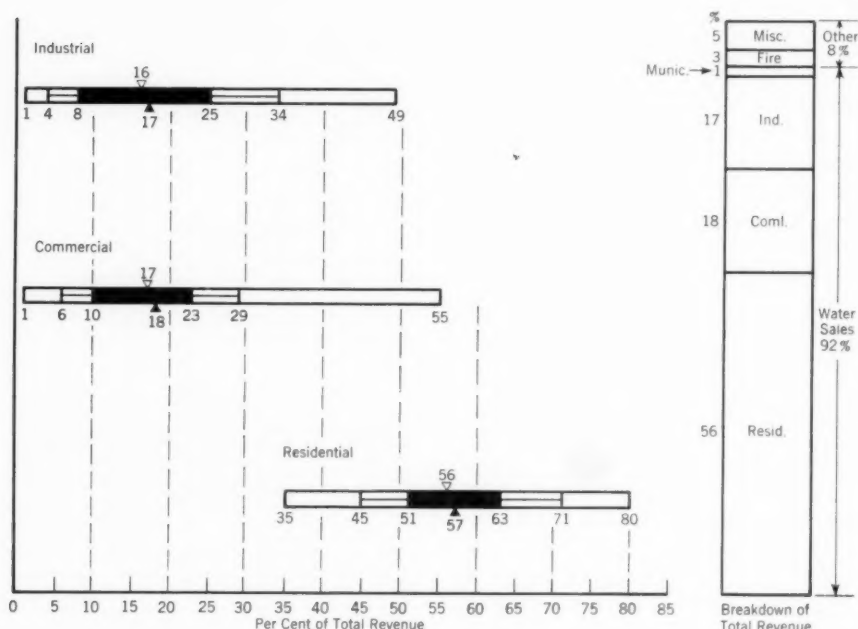


Fig. 9. Sources of Revenue

The three bar graphs at left show the percentage of total revenue obtained from the three main service classes by 78 publicly owned utilities throughout the United States (excluding Wisconsin). The chart at right shows the breakdown of total revenue for these cities.

22). Commercial sales increased in importance from 15 to about 25 per cent of total revenue with increasing size; industrial revenue varied erratically with size of city between limits of 15–25 per cent of total revenue.

For the 78 cities as a group (Fig. 9),

the water sold.) These three classes together furnished 91 per cent of the revenue.

Adding the approximately 1 per cent reported as income from municipal sales brings the sum of water sales revenue to 92 per cent of total revenue.

The sum of public and private fire service charges (still excluding Wisconsin) was found to account for an additional 3 per cent, and miscellaneous income provided the remaining 5 per cent of total revenue. Although the sum of these minor sources of income averaged only 9 per cent for the 78 cities under discussion, some utilities reported income from one or another of these sources in amounts constituting as

annual revenue; 40, from 4 to 8 per cent; 29, from 8 to 16 per cent; and 19, over 16 per cent.

Operation and Maintenance Costs

The sum of operation and maintenance costs of publicly owned utilities divided by the retail population served gave per capita figures varying from \$2 to over \$12, with mean and median values being \$5.50 and \$5.18, respec-

TABLE 23

Operation and Maintenance Costs of Publicly Owned Utilities, by Volume Groups

Volume Group	No. of Cities	Costs—\$/cap.*		No. of Cities	Costs—\$/mil gal†	
		Mean	Median		Mean	Median
1	65	5.55	5.28	67	163	155
2	104	5.63	5.36	98	122	121
3	55	5.77	5.34	53	114	112
4	49	5.82	5.22	48	109	96
5	37	4.90	4.79	36	98	90
6	43	5.35	5.04	40	92	88
7	35	4.93	4.72	34	83	81
1-7	388	5.50	5.18	376	118	110
1-7 (1950)	314	4.33	3.97	311	98	88
1-7 (1945)	352	3.01	2.75	355	76	68

* Per capita figures based on retail population served.

† Per million gallons produced.

much as 15-20 per cent of total revenue.

Free Service Value

Free service value may be considered potential revenue which is written off as a concession or courtesy to municipal or other governmental customers, schools, hospitals, and the like. In many cases it includes an estimate, often nominal, of fire service value. Of the 234 cities answering the question on this subject, 98 reported no free service; 48 reported an amount equivalent to 4 per cent or less of their total

tively (Table 23); the range of most common occurrence was \$4-\$6 per capita. This cost figure, based on retail population only, is again open to criticism because a number of cities serve large areas on a wholesale basis. As was true for per capita revenue, variation by size or volume was lacking.

When calculated in terms of dollars per million gallons produced, operation and maintenance costs were found to vary somewhat by population group but a good deal more by volume group—from about \$160 for Volume Group 1 to just over \$80 for Volume Group 7.

TABLE 24
Total Expense of Publicly Owned Utilities

Pop. Group	No. of Cities	Total Expense—\$/cap.*		Volume Group	No. of Cities	Total Expense—\$/mil gal†	
		Mean	Median			Mean	Median
1	146	6.00	5.88	1	67	172	160
2	91	5.87	5.36	2	98	126	124
3	54	5.41	5.21	3	53	118	112
4	54	5.21	5.19	4	48	114	102
5	17	5.16	4.92	5	36	108	94
6	26	5.03	4.87	6	40	96	95
				7	34	85	83
1-6	388	5.68	5.36	1-7	376	123	113

* Per capita figures based on retail population served.

† Per million gallons produced.

These values are slightly more than half of total revenue.

Analysis by treatment types indicated that cities in the filtration class reported operation and maintenance costs about \$20 per million gallons above those in the minor-treatment group, with softening costs being \$30 per million gallons above filtration. These cost differentials were in reverse order from those noted for revenue (filtration \$30 over minor, softening \$20 over filtration), but the overall difference between the

minor and softening groups was roughly \$50 per million gallons for both expense and revenue. The mean and median cost figures, respectively, were: for 130 utilities with minor treatment—\$97, \$92 per million gallons; for 158 with filtration—\$118, \$112; for 88 with softening—\$148, \$141.

Taxes and Miscellaneous Expense

Taxes and miscellaneous expense were each reported by not more than one-fourth of the publicly owned utili-

TABLE 25
Earnings of Publicly Owned Utilities

Pop. Group	No. of Cities	Earnings—\$/cap.*		Volume Group	No. of Cities	Earnings—\$/mil gal†	
		Mean	Median			Mean	Median
1	146	4.75	4.30	1	67	128	112
2	91	5.10	4.75	2	98	108	93
3	54	4.62	4.45	3	53	104	97
4	54	5.09	5.18	4	48	93	82
5	17	4.71	4.58	5	36	104	98
6	26	4.19	3.75	6	40	92	85
				7	34	75	66
1-6	388	4.80	4.55	1-7	376	104	92

* Per capita figures based on retail population served.

† Per million gallons produced.

ties surveyed, and were quite small, with few exceptions. Together they constituted approximately \$0.20 per capita as an annual expense item, or about \$4 per million gallons, with taxes the smaller item.

In tabulating the survey data, an effort was made to include as an expense item only taxes actually levied by a branch of government, and to show

cases; 1-3 per cent in 25 cases; and over 3 per cent in 39 cases.

Total Expense

As defined for purposes of this data survey and analysis, total expense (Table 24) is the sum of operation and maintenance costs, taxes, and miscellaneous expense. In these terms, total expense for publicly owned utili-

TABLE 26
*Disposition of Total Revenue of Publicly Owned Utilities **

1	2	3	4	5	6	7	8	9	10
Volume Group	No. of Cities	Total Revenue	Operation and Maintenance	Taxes and Miscellaneous	Debt Service†	Capital Expense	Paid to General Funds	Depreciation‡ and Reserves	Total Col. 6-9
Amount—\$/mil gal§									
1	47	289	159	7	59	29	10	25	123
2	79	232	122	3	45	29	11	22	107
3	45	217	113	2	40	24	10	28	102
4	38	196	103	5	36	27	10	15	88
5	30	206	94	7	45	27	16	17	105
6	33	188	90	5	40	20	18	15	93
7	31	156	82	2	33	14	11	14	72
1-7	303	221	114	4	44	26	12	21	103
1-7 (1950)	181	177	93	3	(24)	(6)	(15)	(36)	81

* Data rounded off, using mean and median values. Total of Col. 4-9 equals Col. 3; difference between Col. 3 and sum of Col. 4 and 5 is defined as "earnings" and equals Col. 10. Wisconsin cities excluded.

† Interest, debt retirement reserve, and bonds retired.

‡ Cash only.

§ Per million gallons produced.

|| As reported; however, wording of 1950 questionnaire permitted understatement of capital expense and overstatement of reserves.

all contributions or assessments in lieu of taxes as transfers to general funds (Survey Table 4, Col. 37). There remained 81 publicly owned utilities which paid taxes. Of these, 42 reported taxes amounting to 1 per cent or less of total revenue; 21, from 1 to 3 per cent; and 18, over 3 per cent.

Out of 90 cities reporting miscellaneous expenses, the amount was 1 per cent or less of total revenue in 26

ties was generally about \$5.50 per capita or \$118 per million gallons. Total expense amounted to roughly 53 per cent of total revenue.

Earnings

For want of a better term, the word "earnings" was used in the survey to mean the difference between total revenue and total expense as previously defined. Earnings (Table 25) ranged

from more than \$16 per capita down to a negative value or "loss" of \$1, with the most common range being \$4.50-\$5 per capita annually. In terms of production, this difference ranged from \$380 per million gallons down to a value of minus \$33, with \$90-\$105 per million gallons being most common.

TABLE 27

*Frequency Data on Disposition of Earnings by Publicly Owned Utilities **

Amount \$/mil gal†	Debt Service‡	Capital Expense	Paid to General Funds	Depre- ciation§ and Reserves
No. of Cities				
withdrawal none	40	77	135	17 57
under 10	24	12	27	30
10-19	19	31	19	33
20-29	26	24	11	24
30-39	20	20	7	26
40-49	16	17	7	10
50-59	11	9	5	7
60-69	20	13	3	3
70-79	11	7	3	3
80-89	6	6	2	3
90-99	8	2	2	2
100-149	20	4	2	8
150 or more	4	3	2	2

* Analysis for 225 cities (in Volume Groups 2-6) reporting complete disposition. Wisconsin cities excluded.

† Per million gallons produced.

‡ Interest, debt retirement reserve, and bonds retired.

§ Cash only.

No trend on a per capita basis was observed in the difference between revenue and expense. On a volume basis, however, this difference was found to vary from about \$120 per million gallons for Volume Group 1 to \$70 for Volume Group 7, with the important qualification that the average values for Groups 2 through 6 did not

vary a great deal from \$100. For 225 publicly owned utilities in these five volume groups (again excluding Wisconsin cities because of their distinctive accounting procedures), a detailed analysis was made of the disposition of earnings (Table 26 and 27, Fig. 10)—

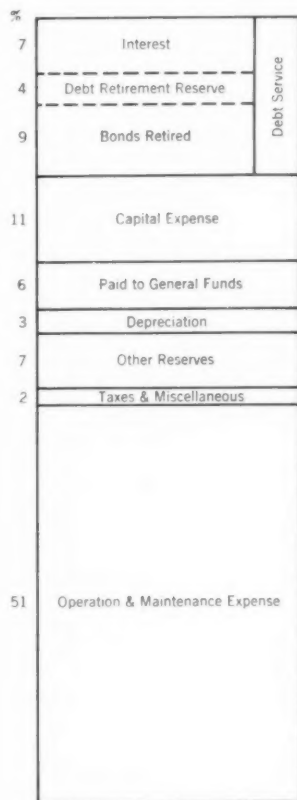


Fig. 10. Disposition of Revenue

The 225 publicly owned utilities on which this chart is based had a total revenue of about \$213 per million gallons produced (average of mean and median). "Depreciation" refers only to cash actually set aside. "Other reserves" includes all surplus funds after other disposition as shown.

that is, of the 47 per cent of total revenue remaining after total expenses were subtracted.

Disposition of Earnings

The data survey requested publicly owned utilities to provide a breakdown of earnings disposition into: debt service (interest, debt retirement, and reserve for debt retirement); capital expense; payments to general funds or regional authorities; and reserves (cash depreciation reserve and general utility reserve or surplus).

Debt service proved to be the largest element, accounting for 20 per cent of total revenue; only 40 of the 225 cities in this analysis reported nothing in this category. Next was capital expenses (11 per cent), reported by two-thirds of the cities; then reserves (10 per cent), reported by three-fourths; finally, payments to general funds, reported by only 90 cities, accounted for the remaining 6 per cent. This disposition appeared to be essentially unaffected by size of city.

Only 50 of the 225 cities set aside funds for actual cash depreciation reserves; 82 cities allocated an amount for depreciation as an accounting record only, without actually setting funds aside; 133 reported funds allocated to other reserves or to surplus; and 74 reported either no disposition to reserves of any kind or an actual withdrawal from reserves.

Operating Ratio

As defined in the survey tabulation, operating ratio is the proportion of total expense to total revenue. For 388 publicly owned utilities the mean value was 1:2.0 and the median 1:1.8; the greatest frequency was in the range of 1:1.4 to 1:2.1. Cities of medium size appeared to be achieving mildly better

coverage of expense than either the smaller or larger cities.

Capital Additions

The survey form requested data on funds raised for capital additions from prior earnings, from general-obligation or revenue bonds, and from other

TABLE 28
*Sources of Funds for Capital Additions,
Publicly Owned Utilities*

Pop. Group	No. of Cities	Prior Earnings	G.O. Bonds	Revenue Bonds	Bank Loans and Other
		No. of Cities*			
1	95	78	12	16	5
2	76	58	17	15	2
3	42	28	8	13	2
4	39	32	10	18	—
5	13	9	1	9	1
6	20	17	5	7	3
1-6	285	222	53	78	13
	Total Raised	Percentage of Funds Raised			
1	100	29	39	29	3
2	100	26	49	24	1
3	100	20	14	64	2
4	100	20	24	56	—
5	100	36	5	54	5
6	100	44	24	25	7
1-6†	100	27	33	38	2

* As some cities reported more than one source, total cities in last four columns exceed figures in second column.

† Percentages weighted by number of cities.

sources. This information did not lend itself easily to analysis, but some general comments are possible.

Total funds raised by publicly owned utilities were most commonly in the range of \$3-\$5 per capita. Over three-fourths of the 285 cities reporting raised at least a portion of needed

funds from prior or current earnings; 53 cities reported new financing through general-obligation bonds and 78 through revenue bonds (Table 28).

In terms of dollar volume, revenue bond financing raised more than 50 per

cent of the money for Population Groups 3, 4, and 5, and 38 per cent for all cities reporting. General-obligation bonds were next with 33 per cent; prior earnings furnished 27 per cent; and all other sources, the remaining 2 per cent.

TABLE 29

Frequency Data on Reserves, Debt, and Book Value, for Publicly Owned Utilities

Amount \$/cap.	Depreciation Reserve	Surplus in Reserve	Funded Debt	Book Value	
				Total Plant	Distr. System
				No. of Cities	
none	68	51	35		
under 10	45	107	56		
10-19	37	27	32	3	12
20-29	40	9	31	6	14
30-39	6	12	29	25	33
40-49	4	8	25	18	42
50-59	3	4	23	43	21
60-79	2	6	16	76	25
80-99		3	10	67	9
100 or more	—		11	73	4
17,* 16†	205	—			
12,* 5†		227	—		
33,* 29†			268		
82,* 76†				311	
48,* 45†					160

* Mean.

† Median.

TABLE 30

Book Value of Publicly Owned Utilities

Volume Group	No. of Cities	Book Value—\$1,000,000/mgd*					
		Min.	Max.	Mean	1st Q.	Median	3rd Q.
1	50	0.16	1.67	0.81	0.52	0.78	1.06
2	76	0.12	1.99	0.77	0.47	0.65	0.95
3	42	0.18	1.87	0.62	0.40	0.56	0.78
4	35	0.12	1.38	0.62	0.45	0.55	0.71
5	28	0.12	1.04	0.60	0.37	0.53	0.76
6	38	0.13	1.38	0.56	0.38	0.51	0.72
7	24	0.25	0.75	0.46	0.34	0.42	0.61
1-7	293	0.12	1.99	0.67	0.41	0.59	0.81

* Per million gallons produced daily.

For Population Groups 1 through 4, the amounts drawn from prior earnings were generally in the range of \$50,000–\$100,000, while the amounts raised by bonding were typically \$250,000–\$500,000 for a single bond issue.

Reserves and Debt

Information was also requested on depreciation reserve funds, surplus income held in reserve, and funded debt. After calculation on a per capita basis, these data were analyzed for typical values (Table 29).

Depreciation reserve funds of publicly owned utilities ranged generally from none to \$30 per capita, with mean and median values of \$17 and \$16 per capita, respectively. Surplus in reserve had an even broader spread, but was most common from none to \$10; mean and median values were \$12 and \$5 per capita. Funded debt exhibited the greatest variation, with mean and median values near \$30 per capita; many cities, however, reported over \$50 and some more than \$100 per capita of funded debt.

A further analysis was made for 194 cities reporting each of the above three items, after summing the values algebraically (considering debt a minus value and reserve funds as plus items). The result was a healthy picture (Fig. 11), with 110 cities on the minus side, 9 at zero, and 75 on the plus side, showing cash reserves exceeding debt. For the 194 cities, the overall mean value was a net debt of \$12, with a median value of only \$7 net debt per capita—certainly a nominal amount in view of the \$2 per capita allocated annually to debt service by public utilities.

Book Value

Book value of total plant was found to vary most commonly from \$50 to \$90

per capita for publicly owned utilities, with mean and median values near \$80 (Table 29). No trends by population or volume were apparent. The survey returns provided a breakdown of book value into four elements—supply and transmission, treatment and pumping, distribution system, and general property and equipment. A further study was made for the 160 cities providing this information in sufficient detail.

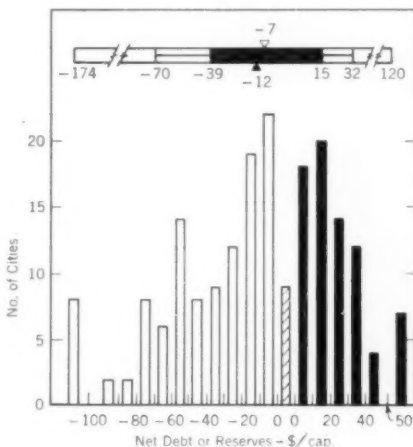


Fig. 11. Net Debt or Reserves

These data are for 194 publicly owned utilities providing sufficient data. (Black bars indicate excess reserves over debt; white bars, excess debt over reserves).

It was found that the distribution system alone was the largest single element in terms of book value; most typically, this item accounted for \$30–\$50 per capita (regardless of size of city), with mean and median values of \$48 and \$45, respectively (Table 29). General property and equipment was a minor item, accounting for only about \$2 per capita.

Supply and transmission, lumped with treatment and pumping, proved to be the variable factor, as could be anticipated. Book values for these elements totaled about \$11 per capita for ground supplies with minor treatment,

gallons per day production. In these terms, there was a definite variation from roughly \$750,000 per million gallons per day for Volume Group 1 to somewhat under \$500,000 for Volume Group 7 (Table 30). Variations were

TABLE 31
*Revenue Sources and Disposition—Wisconsin and Other Utilities**

Item	Wisconsin (Publicly Owned)		Publicly Owned (Except Wisconsin)		Privately Owned	
	\$/mil gal†	per cent	\$/mil gal†	per cent	\$/mil gal†	per cent
<i>Revenue sources</i>						
Residential	67	40	123	56	203	62
Commercial	22	13	40	18	56	17
Industrial	38	23	38	17	36	11
Municipal	3	2	2	1	3	1
Fire	34	20	7	3	23	7
Miscellaneous	3	2	11	5	7	2
<i>Total</i>	167	100	221	100	328	100
<i>Revenue disposition</i>						
Op. and maint. costs	92	55	114	51	136	42
Taxes	1	1	2	1	81	25
Miscellaneous	2	1	2	1	3	1
To reserves	27	16	21	10	34	10
To general funds or dividends	25	15	12	6	35	11
Capital expense	8	5	26	11	8	2
Debt service‡	12	7	44	20	31	9
<i>Total</i>	167	100	221	100	328	100

* Figures are generalized from mean and median values.

† Per million gallons produced.

‡ Interest, debt retirement reserve, and bonds retired.

\$37 for surface supplies with minor treatment, \$30 for surface supplies with filtration, \$20 for ground supplies with softening, and \$35 for surface supplies with softening. Where the treatment works were not extensive, the supply and transmission facilities often more than made up the difference, as in the case of impounding reservoirs or major transmission projects.

Book value was also calculated in terms of total dollar value per million

rather broad, as might be expected in view of the varied supply and treatment combinations included.

Comparison of Wisconsin and Other Publicly Owned Utilities

The returns from 20 publicly owned Wisconsin utilities as a group were sufficiently different in revenue pattern and disposition of available funds to merit separate analysis (Table 31).

These differences, in part at least, were very likely due to the control exercised by Wisconsin's Public Service Commission.

Although the sum of public and private fire service charges was only 3

Wisconsin water rates were roughly 30 per cent less than elsewhere (\$1.85 per 1,000 cu ft, as against \$2.60), while per capita water use (160 gpcd) was about 20 per cent higher. Revenue per million gallons was \$167, ap-

TABLE 32
*Comparison of Publicly and Privately Owned Utilities**

Item	Public		Private		Per Cent Above or Below Public†
	Mean	Median	Mean	Median	
<i>Production and sales</i>					
Production—gpcd	139	126	120	102	-14
Distribution—gpcd	121	108	103	81	-16
Per cent sold	84	85	86	85	+1
<i>Physical system</i>					
Distribution mains—miles/1,000 pop.	2.6	2.5	2.3	2.3	-10
Valves per main-mile	13.0	12.0	12.6	12.4	0
Hydrants per main-mile	7.4	7.2	6.6	6.4	-11
Distribution storage—days	1.5	0.9	0.9	0.7	-33
Employees per 1,000 pop.	0.93	0.88	0.75	0.76	-17
<i>Financial*</i>					
Annual revenue per service—\$					
Residential	25	23	33	31	+33
Commercial	142	87	116	98	-7
Industrial	1,400	975	1,200	770	-17
Water sales revenue—\$/mil gal	210	196	300	290	+44
Public fire service charge—\$/hydrant/yr.	32	30	42	40	+32
Depreciation reserves—\$/cap.	17	16	16	14	-9
Surplus in reserve—\$/cap.	12	5	8	7	-12
Funded debt—\$/cap.	33	29	28	26	-13
Book value—\$/cap.	82	76	68	62	-18

* See also Tables 31 and 33.

† Weighted according to treatment type and volume group.

per cent of total revenue for other publicly owned utilities, it amounted to 20 per cent for the Wisconsin cities reporting—certainly a much more realistic concept of fire protection value. (Consequently, the percentages represented by other sources of revenue were proportionately less.) Payments to general funds in lieu of taxes, however, represented 15 per cent of the revenue dollar in Wisconsin, compared to 6 per cent for other publicly owned utilities.

proximately 25 per cent less than elsewhere.

Privately Owned Utilities

The 1955 survey included returns from 59 privately owned utilities representing every population and volume group, all treatment types, and every geographic region, although Pennsylvania, New York, and the New England area were most heavily represented. As a group, private companies exhibited substantial physical and

financial differences from publicly owned utilities.

Table 31 (previously referred to) summarizes the sources of the revenue dollar and its ultimate disposition for privately owned, publicly owned (except Wisconsin), and publicly owned Wisconsin utilities. Residential sales income was the largest single revenue source for each of the three groups,

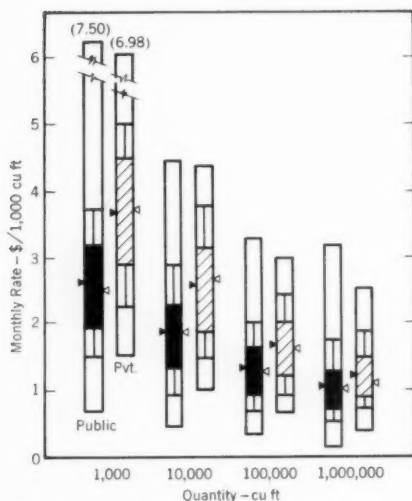


Fig. 12. Rates of Publicly and Privately Owned Utilities

The left-hand bar in each pair applies to publicly owned utilities; the right-hand bar, to privately owned.

but particularly so for private companies. Distribution of funds available after operating costs and taxes was more varied, with the pattern for Wisconsin resembling that for privately owned utilities in some respects (less debt service, lower capital expense). For privately owned utilities, both debt service and capital expense were less than for publicly owned utilities; the

difference was made up in part by heavier dollar allocation to reserves and also by dividends to stockholders substantially exceeding the contributions made by publicly owned utilities to general funds.

Physical and some further financial differences between publicly and privately owned utilities are summarized in Table 32, which evaluates these differences in terms of weighted percentages. In per capita production, privately owned utilities were 14 per cent lower; the difference in percentage of production sold is not significant.

With respect to physical system, some interesting differences were noted. Private companies were about 10 per cent lower in main mileage and in hydrants per mile of main; they were one-third lower in distribution storage. As to employees per 1,000 population, private companies as a group reported only 5 for every 6 employed by publicly owned utilities. Part of this difference may be accounted for by clerical or other public employees who spend part or all of their time in inspection, accounting, or other work not directly related to the water department.

With regard to reserve funds and funded debt, private companies were less extended in either direction, and were probably in a position comparable to that of publicly owned utilities, disregarding stockholders' equity.

Analysis of total book value indicated an appreciable difference, which was found to occur chiefly in supply and treatment works, as the book value of the distribution system alone was essentially the same for both publicly and privately owned utilities.

In the area of rates and earnings (see Table 33 for 1955), privately owned utilities were heavily on the plus side of the comparison. Monthly rate

schedules for private companies were consistently higher (Fig. 12). The difference ranged from 52 per cent at the 1,000-cu ft step to 22 per cent at

dustrial service revenue was less on this basis than for publicly owned utilities because of substantially lower sales volume per account.

TABLE 33
Comparison of 1945, 1950, and 1955 Survey Data *

Item	1945		1950		1955	
	Public	Private	Public	Private	Public	Private
Production— <i>gpcd</i>	126	117	139	124	139	120
Distribution*— <i>gpcd</i>	99	103	111	99	121	103
Per cent sold	81	83	83	83	84	86
Monthly rates—\$						
1,000 cu ft	1.89	2.46	2.23	2.82	2.62	3.70
10,000 cu ft	14.10	16.70	16.80	20.10	19.00	25.90
100,000 cu ft	93	118	117	128	134	166
1,000,000 cu ft	785	945	935	925	1,060	1,220
Min. charge—\$			1.00	1.00	1.20	1.52
Allowance on min.— <i>cu ft</i>			490	395	430	360
Revenue						
Water sales, per residential service— \$/yr.	17	21	20	24	25	33
Total—\$/ <i>cap.</i>	5.98	7.65	7.94	9.20	10.65	12.16
Total—\$/ <i>mil gal</i> †	151	182	182	234	228	330
Expense—\$/ <i>mil gal</i> ‡						
Op. and maint.	76	70	98	103	118	136
Miscellaneous	‡	‡	3	2	3	3
Taxes	1	39	2	53	2	84
Total	77	109	103	158	123	223
Op. and maint.—\$/ <i>cap.</i>	3.01	3.22	4.33	3.90	5.50	4.88
Earnings—\$/ <i>mil gal</i> ‡§	74	73	79	76	105	107
Book value—\$/ <i>cap.</i>	52	60	66	63	82	68
Debt—\$/ <i>cap.</i>	17	28	25	28	33	28

* Mean values throughout. "Distribution" includes sales and free for 1955, but sales alone for 1945 and 1950.

† Per million gallons produced.

‡ Included above.

§ Total revenue less total expense as above.

1,000,000 cu ft. With these higher rate schedules, privately owned utilities reported 44 per cent more water sales revenue per million gallons produced. Revenue per residential service was 33 per cent higher. Commercial and in-

Operation and maintenance costs per million gallons were 19 per cent higher for privately owned utilities, while miscellaneous expense was the same. Taxes represented the key difference. Analysis of the private companies' tax

bill (approximately \$80 per million gallons) revealed the following division: local taxes, 34 per cent; state, 11 per cent; and federal, 55 per cent, or \$45 per million gallons for this portion alone.

The above expense items totaled approximately \$100 per million gallons

only as percentages, but in terms of dollars, since utility growth must still be financed by dollars rather than percentage points.

In 1945 privately owned utilities were operating with rate schedules about 30 per cent higher than those of publicly owned utilities. In the ensuing 10 years, the latter's rates increased about 40 per cent, by fairly equal steps in each 5-year period. Privately owned utilities, on the other hand, raised their rates approximately 60 per cent over this 10-year period, with the increase from 1950 to 1955 being almost double that for the first 5 years. As a result, the lower steps of private-company rate schedules in 1955 were 40–50 per cent above those for publicly owned utilities (Fig. 13).

Private companies allowed 11 per cent less water than publicly owned utilities on the minimum bill in 1955, while collecting 33 per cent higher minimum charges. Although both had reduced the water allowance about 5 per cent over the 1950–55 period, private companies increased minimum charges 46 per cent in the same period, compared to only 17 per cent for publicly owned utilities.

How were these increases reflected in revenue? From 1945 to 1955 publicly owned utilities reported an overall revenue increase, in round figures, of \$75 per million gallons, while private companies achieved an increase of \$150—twice as great. The amount of gain by private companies during the second 5-year period was approximately twice that during the first 5 years, coinciding with the pattern of their rate increases. For 1955, private companies reported revenue per million gallons at a level about 45 per cent above that for publicly owned utili-

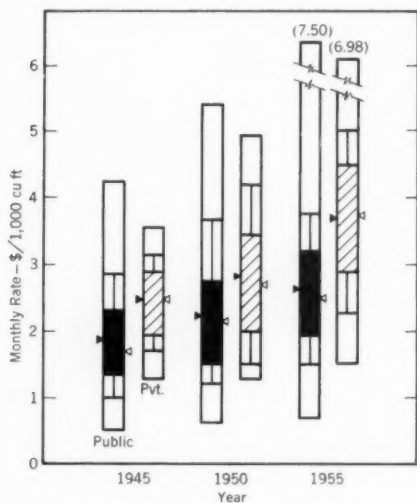


Fig. 13. Comparison of Rates for First 1,000 cu ft, 1945–55

The left-hand bar in each pair applies to publicly owned utilities; the right-hand bar, to privately owned.

(or 85 per cent) more than for public utilities of similar size and character.

1945–55 Comparisons

Reference is again made to Table 33, which contains a summary of rates, revenue, and expense items for publicly and privately owned utilities in the three AWWA data surveys (1945, 1950, 1955). Some of the trends indicated are particularly significant, not

ties, again matching the difference in rates.

Before concluding that private water companies as a group were amassing great wealth, a look at the expense side of the ledger is in order. Over the 1945-55 period, publicly owned utilities experienced an increase of \$40 per mil-

Trends

During the 1945-50 period, the net result of these increases in rates, revenue, and costs was a gain in earnings on the order of \$5 per million gallons for both publicly and privately owned utilities. This represented a gain of about 7 per cent in funds available for

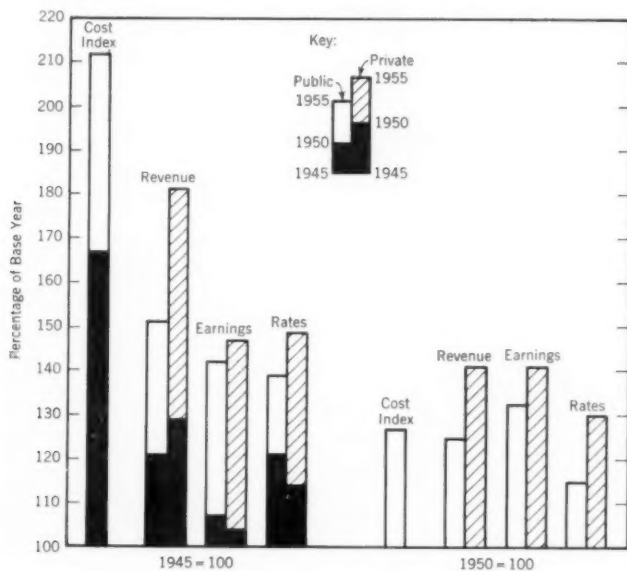


Fig. 14. Cost and Revenue Trends, 1945-55

In the group of bars at the left, 1950 and 1955 mean values for the items shown have been converted into percentages of the mean values for 1945. In the group at the right, 1955 mean values are given as percentages of 1950 mean values. The cost index bars are composites of several construction cost indexes, as explained in the text.

lion gallons in operation and maintenance costs, while this increase for private companies amounted to \$65. For both, the increments during each 5-year period were reasonably alike. Taxes, however, increased \$45 per million gallons for privately owned utilities while remaining nominal for publicly owned.

depreciation, debt service, capital improvements, and reserves—in a period marked by a 65 per cent jump in water works construction costs.

During the 1950-55 period, even more vigorous rate and revenue increases produced a net gain in available funds (after operating expenses

and taxes) of about \$25 per million gallons (30 per cent) for publicly owned utilities and about \$30 (40 per cent) for privately owned utilities. It is worth noting that, in seeking to increase earnings, privately owned utilities are faced with the added problem of diminution of any such increase by the higher taxes automatically incurred.

Figure 14 relates the 1945-55 trends in revenue and earnings to a composite index of water works construction costs.* The failure of water works revenue and earnings, for both publicly and privately owned utilities, to match construction cost rises since 1945 is clearly apparent from the group of bars at the left, which use 1945 as the base year. A more optimistic trend, however, is exhibited by the bars at the right, which use 1950 as the base year.

It may be concluded that, since 1950, publicly owned utility earnings have been keeping up with cost trends, while privately owned utilities have been doing mildly better. But both have still to make up the considerable ground lost during 1945-50. If the relationship between costs and earnings

in 1945 was satisfactory (and there is no reason to believe it was better than that), further rate increases to restore that position appear mandatory. It should be recalled that, as defined in this survey and analysis, it is "earnings" which provide the funds for the expansion of facilities required by continually increasing water demands.

Acknowledgment

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* The indexes used were: Weber, Fick & Wilson Water Works Indexes, for two types of plants (additional data provided by H. H. Fick); Handy-Whitman Index of Water Utility Construction Costs, for small treatment plants and for distribution mains; and *Engineering News-Record* 20-Cities Common Labor Index, for building and heavy construction.

Editor's Note

In preparing this analysis, the authors made up a great many more tabulations (and charts) from the survey data than could be printed here. Some of these are extensions of tables printed in summary form in this analysis; others are different types of breakdowns, or are more detailed, or cover items for which no tabulation was given above (most of this additional material concerns Survey Tables 2-4). Persons doing research work on the 1955 survey may wish to consult the editor about the availability of such additional analytic tabulations on specific points of interest.

Summary of 1955 USPHS Survey of Treatment Facilities in Communities of 25,000 and Over

Ralph Porges

A contribution to the Journal by Ralph Porges, Sr. San. Engr., Robert A. Taft San. Engr. Center, USPHS, Cincinnati, Ohio.

STATISTICS are presumably dry, yet when applied to the vigorous and growing water supply industry they reveal many interesting facets. Statistics are essential to establish norms of water supply practices, to gauge progress in the art and science of water treatment, and to detect the development and acceptance of new methods. Evaluation of data is also essential as a guide for future water supply facility design and water treatment practice.

In the past, extended periods of data paucity have made it extremely difficult adequately to depict the conditions existing during those times. *Water Works Practice* (1) after the 1895 entry states, "Here, complete half-decade records stop. . . ." Water treatment inventories, however, compiled by the USPHS for the years 1910 and 1915 have recently been uncovered. The need for inventory data was apparent to state health departments in the late 1920's, and joint effort with the USPHS resulted in 1931 in an inventory report by the Committee on Water Purification and Treatment, Conference of State Sanitary Engineers (2). The USPHS, at the request of the conference, continued this activity and published a summary of 1940 data (3) and a complete water-sewage inventory for 1945 (4). The most comprehensive water inventory to

date (for the year 1948) was analyzed in the 1953 report, "Statistical Summary of Water Supply and Treatment Practices in the United States" (5).

Water resource planning, necessitated by increasing water demands and current water shortages, has continued to focus interest on water supply information. Because of limited administrative resources, however, recent compilations have been restricted to the larger cities, which nonetheless represent a large majority of the population served by public water supplies. In 1953, Picton (6) of the Department of Commerce reported on communities of 25,000 population and over, with primary concern on facility adequacy. The following year, the USPHS issued two inventories on water supply facilities and water treatment practices, one limited to communities of 25,000 population and over (7) and the other encompassing all water supplies serving populations of 10,000 and greater, plus a 40 per cent sample of communities of between 5,000 and 10,000 population (8). A subsequent inventory was issued for municipal water facilities of communities of 25,000 population and over (9) effective Dec. 31, 1955, which recorded statistics regarding water sources, transmission capacities, treatment facilities, distribution systems, adequacy of distribution and improvements needed. This article summarizes

TABLE 1

State	Total No. of Entries	1950 Census Population 1,000's	Est. Population Served 1,000's	Avg. Daily Output mgd	Avg. Consumption gpd	No. of Services 1,000's	No. of Meters 1,000's
Alabama	7	723	999	105.50	106	206	206
Arizona	2	152	323	54.48	169	79	79
Arkansas	5	261	364	29.39	81	73	73
California	46	5,595	8,118	1,207.11	149	1,797	1,696
Colorado	3	525	784	130.00	166	185	45
Connecticut	26	1,348	1,684	222.82	132	333	262
Delaware	1	110	149	25.00	168	36	35
District of Columbia	1	802	1,103	163.00	148	131	124
Florida	15	1,064	1,750	208.75	119	398	396
Georgia	10	885	1,453	177.53	122	299	286
Idaho	2	61	84	13.43	160	22	22
Illinois	27	4,940	6,024	1,236.11	205	871	523
Indiana	19	1,549	1,794	245.97	137	444	433
Iowa	13	744	843	92.85	110	221	207
Kansas	5	436	645	81.15	126	150	150
Kentucky	7	618	950	118.32	125	193	191
Louisiana	8	972	1,286	152.37	118	275	273
Maine	5	186	244	31.93	131	53	29
Maryland	4	1,024	1,870	252.32	135	430	296
Massachusetts	37	3,079	3,276	378.86	116	582	551
Michigan	20	3,118	4,079	691.83	170	702	678
Minnesota	6	1,021	1,065	114.97	108	232	229
Mississippi	7	290	382	43.60	114	78	74
Missouri	10	1,998	2,541	347.00	137	493	375
Montana	3	104	168	34.00	202	39	16
Nebraska	2	350	438	83.18	190	103	108
Nevada	2	65	102	37.70	370	30	*
New Hampshire	3	145	148	18.25	123	29	25
New Jersey	44	2,469	3,522	495.12	141	558	495
New Mexico	3	151	242	42.69	176	55	55
New York	44	10,626	11,686	1,548.29	132	1,453	704
North Carolina	11	662	848	92.46	109	205	202
North Dakota	2	65	72	7.90	110	16	16
Ohio	35	3,922	5,018	806.98	161	1,140	1,118
Oklahoma	7	579	754	100.36	133	213	198
Oregon	3	453	668	80.30	120	189	186
Pennsylvania	39	4,279	6,575	931.45	142	1,507	1,094
Rhode Island	9	552	716	76.11	106	138	136
South Carolina	4	252	484	53.57	111	92	92
South Dakota	2	78	112	15.50	138	24	24
Tennessee	7	914	1,286	159.85	124	306	297
Texas	24	2,932	4,016	512.88	128	934	937
Utah	3	268	327	68.70	210	76	76
Vermont	1	33	39	2.90	75	7	8
Virginia	11	999	1,362	134.27	99	274	264
Washington	8	949	1,216	364.10	299	297	280
West Virginia	7	335	478	55.37	116	118	116
Wisconsin	18	1,367	1,552	252.90	163	375	323
Wyoming	2	56	66	14.30	218	17	17
Totals	580	64,106	83,704	12,113.52	145	16,478	14,020

* 27 meters.

Summary of Water Facilities in Communities of 25,000 and Over, 1955

Percentage Metered					Ownership				Source of Supply						Laboratory Control			
Unreported	Less than 50%	50-90%	90-99%	Over 99%	Public	Private	Both	Unreported	Ground		Surface		Both		Bacteriological	Chemical	Both	None and Unreported
									No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's				
No. of Utilities																		
			2	5	6	1			2	202	5	797			2	3		2
			1	1	2				1	93				230				
				5	3				1	43	3	234	1	87		1		
1	5		3	37	35	9		2	11	646	19	4,017	16	3,454	5		22	19
4	3	6	3	10	14	10		2			1	622	2	162		1		1
				1	1						20	1,290	6	393	2	1	12	11
				1	1						1	149					1	
				1	1						1	1,103					1	
				1	14	15			11	1,312	2	316	2	122	3		9	3
				1	8	10			1	44	8	1,209	1	200			9	1
				1	2	1			1	55			1	29				2†
3	1	1	5	17	19		1	1	8	564	18	5,389	1	72	4	1	16	6
1	1	1	3	14	12	7		5	5	271	8	670	6	853	1	1	16	1
				8	10	3		6	6	308	6	316	1	219	5	1	5	2
				5	3	1	1	3	3	320	1	205	1	120			4	1
				1	6	1		1	1	48	6	902				1	6	
				1	7	6	2	4	4	337	4	949				1	6	1
1	1	3		2	4	1					5	244					4	1
				2	4						3	1,817	1	53				
	3	1	11	22	37			1	1	97	34	3,112	2	67	1	1	20	15†
	1	1	3	15	20			5	5	385	14	3,634	1	60	2		17	1
				1	5	6		2	2	60	3	670	1	335	1		3	2
				1	3	7		4	4	157	2	175	1	50		1	1	5
	1			4	5	3	7	1	1	35	8	2,414	1	92	2	2	6	
	2			1	2	2	2				3	168			1		2	
				2	2			1	1	125	1	313					1	1
					1	1							2	102				2
					2	1					1	87	2	61				3
22	1	2	5	14	14	11		19	7	409	23	2,479	14	634		1	35	8
				3	2	1			2	208			1	34			2	1
3	11	2	7	21	31	10		3	12	1,086	30	2,584	2	8,017	6		30	8
				10	10	1					11	848					11	
				2	2						2	72					2	
5	1	2	2	25	32	3			7	710	24	3,646	4	662	3	1	30	1
	1			1	5	7			2	70	4	393	1	290		2	3	2
				1	2	3					3	668			1		1	1
5	7	4	3	20	21	16		2	2	124	32	6,178	5	274	1	4	25	9
1				2	6	8	1				5	603	4	113		1	6	2
				1	3	4					4	484				1	3	
				2	2											1		1
				1	6	6	1	2	2	112	4	756	1	40	1		6	
				1	23	23		6	2	490	4	1,784	7	1,291	1	1	16	6
				3	3	3			6	941	11		3	327			1	2†
				1	1	1					1	38			1			
				10	10						10	1,262	1	100	1	2	7	1
	2	1	2	3	8				2	236	4	885	2	95	2		3	3
				2	5	2			1	60	5	356	1	62			7	
				6	16	2			11	493	7	1,059			2	2	9	5
				2	2				1	33			1	33		1		1
46	45	39	85	365	445	104	2	29	126	10,074	357	54,897	97	18,733	48	32	369	131

† One reported no control.

TABLE 2

State	Filters					
	Total		Rapid Sand		Slow Sand	
	No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's
Alabama	4	797	4	797		
Arizona	2	153	2	153		
Arkansas	4	363	3	321		
California	18	2,694	13	2,100		
Colorado	6	543	4	295	1	124
Connecticut	13	988	9	289	4	699
Delaware	1	149	1	149		
District of Columbia	2	1,103	1	551	1	552
Florida	12	1,337	11	1,172		
Georgia	9	1,309	9	1,034		
Idaho						
Illinois	16	2,583	15	2,369		
Indiana	18	1,386	16	1,340		
Iowa	8	565	8	565		
Kansas	4	610	4	610		
Kentucky	7	950	7	950		
Louisiana	8	1,060	7	975		
Maine	2	63	2	63		
Maryland	5	1,844	4	1,795	1	24
Massachusetts	7	471	4	253	3	218
Michigan	11	3,774	11	3,723		
Minnesota	4	1,005	4	1,005		
Mississippi	4	257	4	257		
Missouri	9	2,506	9	2,506		
Montana	2	115	2	88		
Nebraska	2	438	2	438		
Nevada						
New Hampshire						
New Jersey	16	1,582	9	1,337		
New Mexico						
New York	24	2,948	16	2,134	4	185
North Carolina	10	773	10	756		
North Dakota	2	72	2	72		
Ohio	29	4,645	25	4,473		
Oklahoma	5	683	3	356	1	19
Oregon	1	62	1	62		
Pennsylvania	31	5,300	24	3,048	3	1,725
Rhode Island	7	620	6	603	1	8
South Carolina	4	324	4	230		
South Dakota	1	60				
Tennessee	6	1,226	6	1,226		
Texas	21	2,960	18	2,691		
Utah						
Vermont	1	38	1	39		
Virginia	14	1,329	11	1,125	1	36
Washington						
West Virginia	7	478	6	355		
Wisconsin	9	1,165	7	1,091	1	36
Wyoming	1	33	1	33		
Totals	367	51,361	306	43,428	21	3,626

Filtration and Miscellaneous Treatment in Communities of 25,000 and Over, 1955

Filters				Disinfection Only or With Miscellaneous Treatment		Other or Unreported Treatment		Untreated	
Pressure		Other and Unreported							
No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's
5	593	1	43	2 4	202 170			12	629
		1	124	20 5 11	4,795 241 696				
		1	165	4 2 2	413 144 84				
		2	74	6 6	3,441 409				
1	140	1	32	5 1	278 35				
1	14			2 2	226 181				
		2	85	1 16	27 2,805				
		1	24	5 2 3	305 60 125				
8	245	1	51	1 1	35 53	1	25	1	100
				2 4	78 148				
				13 2	1,815 209				
				10 1	8,337 75				
3	444	1	185	5 2 2	373 70 606	6	326	2	75
		1	17	11 3	1,275 96				
		2	171	1 1	160 52				
		2	309	2 2	60 1,056				
1	8	7	527	8 7	327				
		2	95	1 1	160 52				
		1	60	2 2	60 1,056				
		4	269	1 8	33 1,216				
2	90	1	78	1 8	33 1,216				
		3	124	8 1	387 33				
		1	38						
22	1,809	36	2,498	193	31,131	7	351	17	860

TABLE 3

State	Utilities With Disinfection		Treatment					
			Softening		Iron & Manganese Removal		Aeration	
	No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's
Alabama	6	999					1	140
Arizona	6	323						
Arkansas	4	364			1	43	1	43
California	38	7,489	3	837			9	926
Colorado	11	784					1	124
Connecticut	24	1,684					11	661
Delaware	1	149						
District of Columbia	2	1,103						
Florida	15	1,750	8	1,151	3	122	11	917
Georgia	11	1,453						
Idaho	2	84						
Illinois	22	6,025	8	503	6	430	3	173
Indiana	24	1,794	2	188	5	220	7	312
Iowa	13	843	4	383	1	30	3	99
Kansas	5	645	3	405	1	35	3	405
Kentucky	7	950	1	48			3	190
Louisiana	10	1,286	3	670	2	111	4	257
Maine	4	244					1	33
Maryland	6	1,870	1	49			2	467
Massachusetts	22	3,192			1	49	5	313
Michigan	16	4,079	5	543	1	48	1	48
Minnesota	6	1,065	2	868			1	335
Mississippi	7	382			1	32	2	62
Missouri	10	2,541	6	2,280			2	127
Montana	3	168						
Nebraska	2	4,038			1	125	1	125
Nevada	2	79						
New Hampshire	4	148						
New Jersey	27	3,301			5	147	9	517
New Mexico	2	209						
New York	33	11,010			5	1,187	16	9,345
North Carolina	11	848						
North Dakota	2	72	2	72			2	72
Ohio	30	5,018	14	1,892	1	40	5	248
Oklahoma	7	754	2	327				
Oregon	3	668						
Pennsylvania	42	6,575	4	547	4	364	4	405
Rhode Island	10	716			1	16	6	600
South Carolina	5	484					1	120
South Dakota	2	112			1	60		
Tennessee	7	836			1	450	3	794
Texas	29	4,016	8	689	1	200	10	560
Utah	7	327						
Vermont	1	38						
Virginia	15	1,362			2	67	8	696
Washington	8	1,216						
West Virginia	7	478	1	42	1	60	4	351
Wisconsin	17	1,552	1	38	3	106	5	284
Wyoming	2	66					1	33
Totals	550	81,588	78	11,533	48	3,942	146	19,782

Treatment Methods Other Than Filtration, in Communities of 25,000 and Over, 1955

Treatment						No. of Utilities Reporting Natural Fluorides		
Taste & Odor Control		Corrosion Correction		Fluoridation				
No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's	No. of Utilities	Est. Pop. Served 1,000's	Less Than 0.5 ppm	0.5-0.9 ppm	More Than 0.9 ppm
2	153	4	797	1	70	1		
3	321	2	243	1	201	1		
10	1,497	14	1,479	2	1,541	6	3	
4	498			1	124	1		4
3	110	13	952	1	85			
2	1,103	2	1,103	2	1,103			
4	493	5	256	4	701	6	1	
3	351	9	1,309	4	288	1		
						1	1	
11	5,287	4	4,648	5	286	3		2
12	1,140	2	165	9	795	7	1	
7	535	3	384	4	252	5	3	1
3	325	2	285			1	1	
6	902	1	52	4	740			
3	232	5	345			4		1
1	30	1	30					
2	75	5	1,844	6	1,870	5		
2	154	5	302	1	31	2		
10	3,655	4	286	9	640	7		
3	670	1	25	1	335	1		
2	190	1	140	1	50	1		
3	166	1	750					1
2	115	1	60			2	1	
1	313						1	
1	55					1		
		1	14	2	28			
8	1,342	10	1,646	4	100			
		1	34			1	2	
12	864	11	1,070	8	616			
8	680	11	848	6	473	4		
2	72	2	72	1	41	2		
20	3,925	13	2,049	5	526	12	2	
1	290	2	328	3	576	2		2
16	1,815	16	2,400	5	909	2		
4	212	7	268	6	580	1		
4	324	5	484			1		
1	250	5	512	2	282	1		
12	2,427	6	456	3	309	8	2	4
		1	47					
				1	39			
10	1,103	14	1,329	11	1,019	3		
1	648	1	39					
6	418	5	306	6	436	3		
6	1,059			11	1,283	2		1
						1		1
211	33,799	196	27,357	130	16,329	99	18	17

the 1955 inventory, presents some conclusions, and depicts possible trends.

Collection of Data

The usual method of state health department-USPHS cooperation was utilized for collection of the data. The state health departments secured the information from the local facilities and transmitted it to the Department of

TABLE 4
Classification of Entries

Items	Utilities	
	No.	%
Total entries	580	100
Sources of supply		
Surface	357	61.6
Ground	126	21.7
Both ground and surface	97	16.7
Ownership		
Public	445	76.7
Private	104	18.0
Both	2	0.3
Unreported	29	5.0
Laboratory control		
Bacteriological	48	8.3
Chemical	32	5.5
Both	369	63.6
None or unreported	131	22.6
Metering		
Less than 50%	45	7.8
50-90%	39	6.7
90-99%	85	14.7
Over 99%	365	62.9
Unreported	46	7.9

Health, Education, and Welfare, where it received final review. Doubtful items were referred back to the state health departments for ultimate resolution. It is recognized that there are omissions and that errors, no doubt, still persist. It is believed, however, that these errors are of a minor nature and probably do not effect the overall accuracy of the results.

Prior to analysis, the data were scanned for possible duplication where several communities are served by one system or where several systems are interrelated. To interpret the data properly, it was necessary to have detailed knowledge regarding the interrelationship of metropolitan water supply as it occurs in eastern Massachusetts, Southern California, northern New Jersey, and elsewhere. For example, the Metropolitan District Commission of Massachusetts serves eighteen inventoried communities, which individually reported a total population served by district water of 1,716,000. This figure is in close agreement with the 1,812,000 reported by the commission. The average use of district water reported by the eighteen communities totalled 202 mgd, compared to 197 mgd reported by the commission, again a close check. To eliminate duplication in the state total, the report of the commission replaced the eighteen community reports.

If a rational breakdown of data was not indicated, it was arbitrarily assumed that one-half of the supply was in one category and one-half in the other. Data apportionment between two functions as slow-sand and rapid-sand filters in a single plant results in more filter items than plants. Thus, the number of filters does not necessarily total the number of plants, although the population served will be additive.

It was essential in some categories to adjust the data to account for missing entries. Statistics, both for the 1950 census and for estimated population served, were essentially complete. The numbers of services and meters were adjusted to provide for those few instances where figures were not reported. The average daily output was

recorded in practically all instances; other rates were adjusted, as were plant capacity and overload data. The breakdown of the average daily output into its components—domestic, commercial, industrial, public, and other—was reported in only about one-fourth of the cases, so analysis was restricted to the reported entries.

Presentation of Data

Inventory data are summarized by states in Tables 1–3. Table 1 shows population statistics, average daily consumption, services, and meters including a breakdown by percentage metering, ownership, source of supply, and laboratory control. Table 2 summarizes treatment by filtration and miscellaneous treatment and includes that small portion without treatment. Table 3 itemizes the treatment methods other than filtration.

Tables 4–8 illustrate the national statistics and provide a basis for comparison with previous records by which developing trends may be detected. Table 4 includes sources of supply, ownership, laboratory control, and a

TABLE 6

Plant Functions Other Than Filtration

Items	Plants		Est. Pop. Served	
	No.	%	No. 1,000's	%
No. of treatment plants	567	100.0	82,844	99.0*
Disinfection	550	97.0	81,588	97.5
Softening	78	13.8	11,533	13.8
Iron and manganese removal	48	8.5	3,942	4.7
Chemical taste and odor control	211	37.2	33,799	40.4
Corrosion correction	196	34.6	27,357	32.7
Fluoridation	130	22.9	16,329	19.5
Natural fluorides reported	134			
Less than 0.5 ppm	99			
0.5–0.9 ppm	18			
More than 0.9 ppm	17			

* Percentage of estimated population served by all the 580 utilities surveyed (83,704,000).

breakdown by percentage metered. Table 5 contains data on types of filters, disinfection practiced without filters, and untreated supplies. Table 6 presents plant functions other than filtration. Table 7 records water use and plant production including average daily output; maximum hour, day, and month; and average daily use by domestic, commercial, industrial, and public and other consumers. Table 8 depicts an evaluation of water sources, plant capacity, ability of distribution systems to meet maximum demand, and improvements needed.

As of Dec. 31, 1955, there were 580 entries serving populations of 25,000 and over. A community entry may pertain to a municipal water supply, a water system serving several communities, or a private water company. The total 1950 census population of communities within this group was 64,106,456.

The estimated population served as of Dec. 31, 1955, reached 83,704,000, an increase of nearly 3,000,000 over that reported in 1954 (10). This increase is about equal to the population gain in the United States for the year (11). It is estimated that over 17,000

TABLE 5
Types of Treatment Plants and
Miscellaneous Operations

Items	Plants		Est. Pop. Served	
	No.	%	No. 1,000's	%
No. of treatment plants	567	100.0	82,844	99.0*
Filter plants	367	64.7	51,361	61.4
Rapid sand	306†		43,428	51.9
Slow sand	21†		3,626	4.3
Pressure	22†		1,809	2.2
Others and unreported	36†		2,498	3.0
Disinfection only or with misc. treatment	193	34.1	31,131	37.2
Other or unreported treatment	7	1.2	351	0.4
Untreated (completely or partially)	17		860	1.0

* Percentage of estimated population served by all the 580 utilities surveyed (83,704,000).

† Not additive, since some plants have more than one type of filter.

communities in the United States have public water systems serving a total of approximately 118,000,000 people. Thus, the population served included in this 1955 inventory is estimated as 71 per cent of the total served by community water supplies in the United States.

Surface water sources supplied 65.6 per cent of the population served, ground sources 12.0 per cent and both ground and surface sources 22.4 per cent (Table 4). There have been no radical changes in these percentages over the past 8 years (5 and 10).

Ownership statistics indicate that 76.7 per cent were municipally operated, 18.0 per cent privately owned, and 0.3 per cent combine public and private ownership; unreported were 5.0 per cent. Unreported entries dropped 1.1 per cent over 1954, and private supplies increased 0.8 per cent. Resolution of the unreported entries may increase the percentage of private supplies.

Both bacteriological and chemical analyses were conducted at 63.6 per cent of the plants, which is an increase of 6.3 per cent over 1954. Slight decreases were noted in plants practicing only chemical or bacteriological control; those reporting no control or not reporting dropped 3.6 per cent, to 22.6 per cent.

The water systems reported 16,478,000 services and 14,020,000 meters. These figures indicate that an average of about five persons were served per service and about 85 per cent of the services were metered. Table 4 breaks down metering figures into percentage groups. Those communities with minimal metering might realize a per capita use reduction averaging 25 per cent with complete metering (12).

Table 5 presents a breakdown of the various types of filters employed in water treatment plants. Also shown

are those systems using chlorination without filtration and that small portion served without treatment.

Of the 567 treatment plants serving 82,844,000 or 99.0 per cent of the population served, 367 or 64.7 per cent were filtration plants, the majority—306—being rapid-sand installations. Slow sand, pressure, and other filters amounted to 21, 22, and 36, respectively. Disinfection without filtration was practiced by 193, or 34.1 per cent, of the plants.

TABLE 7

Water Use and Plant Output

Classification	Output	
	%	gpcd
580 entries serving 83,704,000		
Avg. daily output	100	145
Max. hour—191 entries	257	373
Max. day—512 entries	162	235
Max. month—502 entries	140	203
206 entries reporting breakdown		
Avg. daily output	100.0	145
Domestic	40.8	59
Commercial	18.0	26
Industrial	24.5	36
Public and other	16.7	24

Because of the small number of untreated supplies, a separate table on this item was not developed. Four states reported twelve untreated ground water supplies serving 697,900 people; in two states, five supplies secured from both surface and ground sources were reported as both treated and untreated. The surface portion was treated in all instances; the untreated ground portion supplied a population of about 162,600. Untreated water supplies are diminishing.

Plant functions other than filtration are shown in Table 6. Of 99.0 per cent of the population served with treated water, 97.5 per cent obtained water that was chlorinated, 13.8 per cent softened water, 4.7 per cent water treated for iron and manganese removal, 40.4 per cent for taste and odor control, 32.7 per cent for corrosion correction, and 19.5 per cent fluoridated. There have been increases in the above treatment practices in recent years. Inferior raw-water quality as result of increased pollution and the need to tap waters of lower quality, coupled with demand for better water, could be influencing factors.

As of Dec. 31, 1955, fluoridated water supplies were used by 1,274 communities serving a total population of 24,401,000 (13). Ten years ago only 232,000 people in three communities had fluoridated supplies. A gain of twelve plants has been recorded in the past year. Natural fluorides were reported by 134 entries.

A heated discussion can be instigated among water works personnel by raising the question, "What is the average daily per capita consumption and how fast is it increasing?" Over the nation, a wide fluctuation in unit values exists. For example, Everett and Bellingham, Wash., reported for 1955 an average per capita consumption of 2,180 and 1,320 gpd respectively. Tacoma, Wash., reported 338 gpcd, but the domestic portion was only 65 gpcd. Obviously, these extremely high values are the result of industrial demands. Each case, then, presents its own unique problem, yet overall statistics as shown in Table 7, must play a part in water resource planning and development.

Increasing use of household equipment as dishwashers and garbage grinders does not necessarily mean increasing the demand for water. This

equipment replaces functions that may have been equally or more wasteful of water. At Jasper, Ind. (14), where studies of rates of water usage before and after installation of grinders were made, no noticeable change in usage by residential consumers was recorded. Another study (15) at Tucson, Ariz., showed that the sewer line with household grinders averages 4.2 gpcd less than the line without garbage grinders.

Among the population group 25,000 and over, the average daily per capita consumption in 1955 was 145 gal (Table 7). This value may be compared to 149 gal in 1948 (5), 148 gal in 1953 (6), and 149 gal in 1954 (10). In recent years, no distinct trend has appeared. A report (12) in 1954 covering communities of 5,000 population and over gave the average daily per capita consumption of 143 gal. It is estimated, considering all water supplies in the United States, that the 1955 consumption per capita would probably fall between 140 and 143 gpd.

With all rates of usage converted to million gallons per day, the maximum hour was reported as 257 per cent of the average day, maximum day as 162 per cent of the average, and maximum month as 140 per cent of the average. Close agreement was observed with the 1954 report (10), which indicated the maximum hour as 231 per cent and maximum day as 163 per cent of the average.

A total of 206 community entries reported on the indicated water usage segments. These averaged 40.8 per cent or 59 gpcd for domestic usage, 18.0 per cent or 26 gpcd for commercial purposes, 24.5 per cent or 36 gpcd for industrial needs, and 16.7 per cent or 24 gpcd for public and other uses. These values check rather closely with the 1954 evaluations of 42.8 per cent (64 gpcd) for domestic, 18.9 per cent

(28 gpcd) for commercial, 24.9 per cent (37 gpcd) for industrial and 13.4 per cent (20 gpcd) for public and other uses. It will be noted that the combined industrial and commercial demand upon municipal water supplies in 1955 amounted to 42.5 per cent. A discussion of industry's stake in public water supplies is of interest (16).

Table 8 shows an evaluation of the various water facility components and provides a summary of the needed improvements. The results show that 203 or 46.9 per cent of the sources had safe yields exceeding 300 per cent of the average daily demand, 84 or 19.4 per cent could yield safely 200-300 per cent of the daily needs, 63 or 14.5 per cent from 150 to 200 per cent of daily needs, and 64 or 14.8 per cent from 100 to 150 per cent of the average daily demand. Nineteen or 4.4 per cent could not supply safely the average daily requirements. These data point to the need for basic water resource planning especially when considering that the maximum daily demand was 162 per cent of the average daily output. A water resource study in the Missouri River Basin (17) showed that over 14 per cent of the communities had inadequate water supplies in 1955 and that by 1975 this figure might increase to 35 per cent. These inadequacies did not consider water quality reported by some 23 per cent in the Missouri Basin as being undesirable in its chemical and physical characteristics.

A study was made of 404 entries reporting data permitting comparison of plant overload with average daily output. Of the reporting entries, overload capacity exceeded the average daily output by over 200 per cent in 56.4 per cent of the plants, fell between 150-200 per cent in 32.6 per cent and was less than 150 per cent in 10.7 per cent of the plants. Picton (6), evaluating 1953

data, reported 58 per cent of the water supply systems as having facilities considered adequate, 21 per cent uncertain, and 21 per cent inadequate.

The average rated plant capacity of the 528 plants reporting this item was 165 per cent of the average daily output

TABLE 8

Evaluation of Yields, Capacities, Distribution, and Improvements Required

Items	Utilities	
	No.	%
Safe yield	433	100.0
Over 300% of avg. daily output	203	46.9
200-300% of avg. daily output	84	19.4
150-200% of avg. daily output	63	14.5
100-150% of avg. daily output	64	14.8
Less than avg. daily output	19	4.4
Plant overload capacities	404	100.0
Over 200% of avg. daily output	230	56.9
150-200% of avg. daily output	131	32.4
Less than 150% of avg. daily output	43	10.7
Distribution systems	580	100.0
Adequate	357	61.6
Inadequate	90	15.5
Unreported	133	22.9
Improvement requirements reported	378*	100.0*
Source, underground	78	20.6
Source, surface	78	20.6
Transmission	158	41.8
Pumping	143	37.8
Treatment	153	40.5
Ground storage	109	28.8
Elevated storage	164	43.4
Distribution system	217	57.4
Other	4	1.1
None	16	4.2
Unreported	202	

* Not additive, since some utilities have more than one requirement.

which is only 3 per cent more than the maximum day demand. The average overload capacity exceeded the rated plant capacity by 25 per cent.

Distribution system adequacy for maximum demand was a reportable item on the inventory sheet; 61.6 per cent of the entries reported that the distribution system was adequate, 15.5 per cent inadequate, and 22.9 per cent failed to report on this item.

It is apparent that considerable effort should be directed toward bringing municipal water facilities up to maximum dependability for future demands. This requirement has been recognized by water works people. For example, 41.2 per cent of the entries stating their needs reported that improvements in source of supply were needed, 40.5 per cent indicated treatment needs, and 57.4 per cent showed needs for the distribution system. Other needs reported were transmission 41.8 per cent; pumping 37.8 per cent; storage 72.2 per cent; miscellaneous 1.1 per cent; no needs 4.2 per cent. Of the 580 entries, 202 or 34.8 per cent failed to report on their needs.

Future Water Demand

The water supply industry must build to meet future demands. It must serve a growing population, increasing uses, expanding industrialization and a constantly enlarging suburbia. Counteracting these factors which tend to increase demand are: [1] control by meters, [2] surveys to eliminate wastage and inadvertent losses, [3] conservation and reuse by industry to reduce costs and waste disposal requirements, and [4] general rising water costs which may prove to be the most effective deterrent to excessive use.

It is believed that these related but generally opposing forces may result in a slightly rising average per capita de-

mand. The per capita demand will rise more rapidly in the smaller communities to approach that of the larger cities. By the year 1975, the average demand in the United States may possibly range between 155 and 160 gpcd.

Industry will continue to demand more water to satisfy its increasing production capacities. Rising costs, stricter control of pollution, and competitive pressures, however, will tend to exert control over industrial uses so that consumption per production unit will probably decrease.

A most important consideration is the growing population. Even though the average municipal per capita consumption from 1948 to 1954 showed only minor variation, the estimated population served by municipal systems of communities having populations greater than 10,000 increased 60 per cent with a corresponding increase in total consumption (12). It is not unreasonable to expect that semirural and even the more populous rural areas will eventually be served by public systems. The United States census (11) estimates that the national population in 1975 may range up to 221,000,000, a 33 per cent increase over the 1955 population. In addition, the trend toward growth of urban and suburban areas will probably continue.

Water use will fluctuate as influenced by climatic conditions; there will be peaks and valleys. Over the next several decades, however, there will be a generally constant and growing demand on the water supply industry.

Acknowledgment

It is not possible to recognize and acknowledge adequately the help and cooperation of all those participating and making possible the basic data inventory. Representatives of communi-

ties and local water facilities, state health department personnel, and members of the USPHS have cooperated in this activity. Sincere appreciation is expressed to all.

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Correction

Since the publication of "A Survey of Operating Data for Water Works in 1955" (May 1957 JOURNAL, pp. 553-696), the following errors in the tabulation have come to light:

City	Table	Page	City No.	Column No.	Reads	Should Read
Antioch, Calif.	4 (I)	642	20	1	29	20
Corpus Christi, Tex.	4 (I)	650	106	3 4	1,198.7 —	— 1,198.7
Springfield, Mo.	4 (II)	684	436	25 26	2,219 25	12,219 139
Wichita, Kan.	3	641	486	13	1.33	133

Evaluation of the Use of Polyphosphates in the Water Industry

—Thurston E. Larson—

A contribution to the Journal by Thurston E. Larson, Head, Chemistry Section, Illinois State Water Survey, Urbana, Ill.

THE statements in this attempt to separate fact from fancy in the sale and use of polyphosphates in water treatment derive from findings which have been described in reliable scientific literature. Several comments are contrary to the implications of sales representatives who lack either adequate training or the capacity to resist the temptation to oversell. Such deficiencies have resulted in misapplications which have not benefited the reputation of polyphosphates in water treatment.

In a broad general sense, all polyphosphates show the same characteristics—with some notable exceptions which are of minor consequence in this discussion. These polyphosphates include the crystalline pyrophosphate, metaphosphate, and tripolyphosphate, as well as a number of glassy polyphosphate blends. Polyphosphates behave chemically in a manner quite different from the well known orthophosphates. In many ways the polyphosphates are remarkable as a class of chemical compounds.

Many claims have been made; some are adequately supported by data, but others are often misinterpretations or inferences which cannot be substantiated by suitable records. In each case the circumstances of the application must be considered. Inferences from

favorable data acquired in one application are not necessarily applicable to another. The first need in any application is a statement of the end to be accomplished.

Softening of Household Water

Data are available to show that about 5–10 ppm polyphosphate are required to counteract 1 ppm hardness. Thus, for example, water with a hardness 300 ppm will require an application of 1,500–3,000 ppm of polyphosphate to soften it, or 6–12 tons per million gallons. On the other hand, considering smaller quantities, 1 oz of polyphosphate would be required to soften 10 gal of water of 300 ppm hardness. Thus, a household job such as dishwashing represents a practical application. Such softening is accomplished by a process called sequestration, or by the formation of soluble calcium polyphosphate and magnesium polyphosphate complexes.

This should not be confused with what is normally considered as threshold treatment—a stabilizing or inhibiting treatment which is designed for another purpose when treating municipal or industrial water supplies. Threshold treatment refers to the application of polyphosphate in a concentration of about 2–4 ppm. This concentration theoretically reduces the

hardness of the water by about 0.5 ppm—for example, from 300 ppm to 299.5 ppm.

Polyphosphates are normally an integral ingredient in dishwashing compounds for restaurants and household use, as well as in many synthetic detergents. A typical dishwashing machine compound contains about 40 per cent polyphosphate, 40 per cent sodium silicate, and 20 per cent soda ash.

Thus, the use of polyphosphate for softening water for domestic purposes is practicable, but exceeds the bounds of ridiculousness when it is implied that the same applies to municipal softening of hard-water supplies.

Cleaning of Wells

As cleaning and wetting agents, polyphosphates have achieved frequent notable success when used for cleaning screened sand and gravel wells. When confronted with a well problem, it is important to be sure, first, that the problem results neither from pump inefficiency, lack of water in the aquifer, nor failures in the column pipe. Where it has been determined that lack of water is due to clogged screen or a clogged water-bearing formation in the immediate area of the screen, treatment with about 30 lb of polyphosphate per 100 gal of water in the well bore has been found successful. Such treatment is often accompanied by the use of 1–2 lb of chlorine or chlorinated lime and, on a few occasions, has been in conjunction with a wetting agent of the non-ionic type. The practice of surging the well periodically during the several hours following the application of the treatment is recognized as highly beneficial. For continued success, it is desirable to repeat the application at scheduled intervals dictated by experience so that incrustation does not reach

the point where this nondestructive type of treatment can no longer be applied with success.

Red Water

Rusty water may occur as the result of the natural presence of iron in the water pumped from ground water wells or it may result from iron dissolved in the water as a product of corrosion.

Iron in well water is normally present in the soluble (ferrous) state. The water is clear until, upon exposure to air or to chlorination, it is converted to the insoluble (ferric) state which reacts with water to form ferric hydroxide, or rust.

Polyphosphates have the property of being able to combine with or sequester soluble iron. They do not combine with or sequester insoluble ferric hydroxide. In view of this property, the more effective use of polyphosphate requires the application of this treatment to the water before it is exposed to air or before chlorination. Subsequent oxidation by air or chlorine will convert the iron to the ferric form, but it remains dispersed until the polyphosphate has lost its dispersing property by reversion to orthophosphate.

The amount of polyphosphate required for this purpose is about 2–4 ppm per 1 ppm of iron in concentrations up to about 2–4 ppm. At higher concentrations of iron, more than 9 ppm polyphosphate is not always beneficial.

As it has been recognized that polyphosphate is an excellent source of phosphorous for the growth of bacteria, it is normally recommended that the concentrated solution of polyphosphate for injection into the water be treated with about 50 ppm chlorine each time the solution is prepared. This prevents the development of a breeding ground

for possible coliform organisms in the polyphosphate treatment solution.

In certain areas where sufficient concentrations of ammonia, methane, or both may be present in the well water, some iron removal water treatment plants are rendered ineffective by bacterial growths in the filter bed. Such growths deplete the oxygen which was dissolved in the water by aeration for the purpose of oxidizing the soluble iron to the insoluble ferric hydroxide prior to filtration. In fact, even though chlorination is subsequently applied to the water effluent, the water mains themselves may be so infected with such growths that chlorine is destroyed by the growths faster than the reverse can occur. Subsequently, such insoluble iron as may be deposited in the mains is redissolved as ferrous iron because of the anaerobic conditions created by the bacterial growths.

Chlorination before filtration has proved to be successful in many cases. In persistent situations it may be desirable to use copper sulfate in conjunction with polyphosphate for the purpose of inhibiting the growth of bacteria while the polyphosphate keeps in soluble form such soluble iron as may be picked up from the mains. The economics of such treatment is not prohibitive for small water plants. Normally, a treatment with 1 ppm copper (2.5 ppm anhydrous copper sulfate) is adequate when applied with more than 2-4 ppm and less than 9 ppm polyphosphate.

Scale Prevention

Scale is defined here as a deposit from hard water and does not refer to either rust deposits or corrosion products. Threshold dosage of polyphosphate in water has the unique power of preventing crystal growth of calcium

carbonate. Although either calcium or magnesium may be responsible for the scale, polyphosphate is effective against calcium carbonate deposits *only*; it has no effect on redissolving or preventing the magnesium hydroxide deposits so frequently encountered where lime softening plants are not operating properly.

The first of four points where calcium carbonate deposits can be controlled is the sand filter. Lime softening plants without sufficient recarbonation to prevent calcium carbonate deposition on sand frequently acquire an accumulation of calcium carbonate on the sand grains. Continuous treatment with polyphosphate in threshold concentrations (2 ppm) has frequently been reported to prevent such depositions. Magnesium hydroxide deposits which may occur at this point are no problem because they do not accumulate on the sand grain and are easily removed during backwashing.

Distribution systems constitute a second point of scale accumulation because lime softening plants with insufficient recarbonation may also deposit a rather heavy calcium carbonate scale in the main as the water leaves the plant. Again, threshold treatment with polyphosphate will prevent this accumulation at this point. However, such plants frequently also produce a water at or near saturation with magnesium hydroxide. Such lime-softening effluents are usually high in magnesium and pH and low in calcium and alkalinity or both. Deposits of magnesium hydroxide in the water main *cannot* be removed or prevented by the use of polyphosphates. There is no record in the literature to indicate the successful use of polyphosphate for this purpose.

Magnesium hydroxide or magnesium silicate, singly or mixed with calcium carbonate or residual alum form a wavy, rippled deposit that has a very serious effect upon carrying capacity. Records are available where the Hazen-Williams *C* value has been reduced from 120 to 90 or 80 with as little as a $\frac{1}{16}$ -in. deposit of this rippled nature. Because polyphosphates will not prevent such a deposit and no chemical is known for postcorrective treatment, the cure is one of prevention and not of treatment.

A third point of scale accumulation is in apartments, hotels, hospitals, and similar places, where three kinds of hardness can be considered:

1. Completely softened water which will not deposit calcium or magnesium scales

2. Unsoftened hard water which usually does not scale in cold water lines (At drinking fountains or faucets, however, scale deposits may build up. Polyphosphates should correct this deposition of calcium carbonate for such hard waters. Scales in hot-water appliances and hot-water lines are usually calcium carbonate. Treatment of this condition with polyphosphate in threshold concentration should also be of benefit if the retention time at the heating point is not sufficient to revert the polyphosphate to orthophosphate.)

3. Lime-softened water, which rarely produces heavy scales in cold water lines (In fact, some calcium carbonate scale is desired for corrosion prevention. Scales in hot-water lines are common, and if the scale is calcium carbonate, polyphosphate can be of benefit, particularly if applied in recirculated systems. If, however, the scale is magnesium hydroxide, which is highly insoluble in hot water, polyphosphate treatment is worthless).

Another property of polyphosphate that should be considered lies in its behavior when exposed to high temperature and to high pH. High temperature and, to a lesser extent, high pH in hot-water tanks and at the heating point, cause a significant reversion of polyphosphate to orthophosphate within a few hours. A number of overdosage instances are on record where the orthophosphate has reacted with calcium to form a calcium phosphate or calcium hydroxyphosphate scale which actually did more harm than good. The rates for reversion for various polyphosphates vary, but there is no record of any polyphosphate that possesses desirable useful properties which is not subject to partial or complete reversion to orthophosphate within a matter of hours under high-temperature conditions.

Magnesium hydroxide scale with or without adsorbed silica in hot-water tanks can easily be removed by flushing with a hose. When such flushing of this highly heat-insulating deposit becomes necessary on a weekly or monthly basis, the water user is justified in complaining.

Scale is also frequently encountered in cooling towers where polyphosphate is frequently a part of the chemical treatment. Continuous treatment by application of polyphosphate alone is usually not completely effective. Such water use and accompanying treatment is complicated by the rate of blowdown, the pH of the water, the general water quality, the reversion rate of the polyphosphate, and the temperature of operation. The problem is frequently one of treatment to prevent corrosion, scale, and slime. Polyphosphate treatment is usually an adjunct to other treatment or is supplemented by pH adjustment, by the addition of chromates, or

zinc salts (or both), by ferrocyanide or organics for corrosion control, and even by chlorine or chlorinated phenols for slime control.

Corrosion

Corrosion is defined as the loss of metal and may be evidenced by failure of a structure, conduit, or container. In the case of ferrous metals, it may be detected by the appearance of iron in the water from the solution of ferrous metal. It may also be detected by the appearance of rust deposits on the water side of the metal. These deposits may be uniform, as in general corrosion, or knobby growths, as in pitting and tuberculation.

The appearance of iron (red water) as a result of corrosion may not be in significant quantities at high velocities because of dilution, but can be considerable at low velocities because of the longer contact time. On the other hand, the corrosion rate necessary to induce structure failure may be greater at high velocities but insignificant at low velocities.

The presence of iron in the water is not necessarily an indication of corrosion, because it may have been present in the water before contact with the metal vessel. The appearance of a rusty scale is not always evidence of corrosion because it may be a deposition of hardness together with iron which was originally present in the water.

Polyphosphates have been reported to be effective in reducing corrosion by domestic waters. The reliable data show this effectiveness only under certain conditions and with certain types of waters. Corrosion prevention cannot be claimed, even though the red water effects of natural iron in the water have been lessened by the use of

polyphosphates, nor can prevention be claimed where red water is avoided by sequestration of this iron corrosion product. Improvement but not prevention can be claimed in situations where pitting-type corrosion is altered to generalized corrosion.

The effectiveness of polyphosphates is progressively greater at increasing turbulent velocities and at increasing concentrations. Under essentially no conditions are polyphosphates effective in stagnant or nearly stagnant water, such as in dead ends or service lines. The only data available on its effectiveness at low velocities appear to indicate a slight increase in corrosion at 0.5 fps. It should be recognized that conditions of 2-5 fps or more of turbulent flow velocities are not experienced continually in all parts of almost any distribution system, and certainly not in communities where the grid has been designed with 5-10 miles of 4- and 6-in. pipe for a 30,000 gpd consumption. Considerable embarrassment could be avoided if vendors as well as superintendents would calculate the velocity of flow in 4-in. dead ends at normal domestic consumption rates by a limited number of families.

In hot-water systems, the corrosion rates are usually greater than in cold. Recirculation improves the effectiveness of polyphosphates or of any inhibitor in hot-water systems, but, because of the low velocity, not in hot water tanks. It can, however, improve the ability of the treatment to maintain such iron as is dissolved by corrosion in solution.

There is room for definition of water quality as related to its corrosive properties. All waters are not equally corrosive and it should be recognized that the quantity of polyphosphate required may vary depending on the water

quality as well as the specific conditions of use. Any large-scale application and most small-scale applications for corrosion control, warrant well planned and complete corrosion testing to establish data on effectiveness at the specific applications and velocities involved.

Cleaning of Water Mains

Reported experiences vary with regard to the effectiveness and even the desirability of using polyphosphates for water main cleaning. The usual procedure consists of mechanical removal of bacterial slime, debris, mineral deposits, or corrosion products. On occasions, little discussed in scientific journals, polyphosphates or other chemicals have been used as an adjunct to mechanical cleaning. No clear, reliable assessment of the value of this function is available, nor is it reasonable to expect a valid evaluation without more exact data than have been published to date.

The use of polyphosphates as an adjunct to mechanical cleaning must be followed by effective water treatment if the cleaning is to have a lasting effect. If the subsequent treatment is done with polyphosphates for corrosion control, the limitations inherent in low-velocity mains must be recognized.

Nonmechanical removal of corrosion products and deposits other than calcium carbonate has been proposed and attempted, often with embarrassing results. It would appear that the primary problem is that of defining the deposit to be removed and the quantity. These unknowns are further complicated by a butcher's guess on the quantity and method of application of polyphosphate. When it is recognized that even the manner of action of polyphosphate on the various unknown deposits or corrosion products is not clearly established, nonmechanical water main cleaning with polyphosphates must be considered as nothing more nor less than a calculated risk. There is no established and proved plan or specification for nonmechanical removal of noncalcareous deposits.

Conclusion

Polyphosphates are a truly remarkable class of chemicals. Their effectiveness for many purposes has been demonstrated in the laboratory and by practice. Their ineffectiveness for other purposes has also been established in the laboratory as well as by experience. It is unfortunate that no specific data are available for the cure-all misapplications which have resulted in disastrous failures and chaotic difficulties.

Revenue-producing Versus Unaccounted-for Water

Committee Report

A report of Committee 4450 D—Revenue-producing Water, presented on May 13, 1957, at the Annual Conference, Atlantic City, N.J., by E. Shaw Cole (Chairman), Pres., Pitometer Assoc., New York, N.Y. Other members of the committee were: Ellwood H. Aldrich, E. Jerry Allen, David Auld, Egbert D. Case, Oswald A. Gierlich, Dewey W. Johnson, Arthur P. Kuranz, Howard W. Niemeyer, W. K. Van Zandt, and Howard R. Wright.

THE increase in the demand for water due to improved living standards, population growth, and industrial expansion is rapidly approaching the limit of the great natural resources. Most communities are finding it increasingly difficult and expensive to enlarge their sources of supply and plant facilities, so that the incentive to conserve their existing supply is greater than ever.

The cost of an additional supply is frequently more expensive than the original construction because of the need to go a greater distance from the community or to develop a new source which has less yield per invested dollar or simply because of inflation. Ground water is being depleted, and water tables are being lowered. The least expensive supplies were developed initially; but even without considering the steady rise in construction costs, future supplies will be almost certain to cost more than the existing ones.

Conservation is, therefore, a fundamental part of water works operation in an established community, due to the direct money savings in operation and the longer range savings from deferred capital costs for plant expansion.

Direct savings can be made in the cost of production by reducing the amount of chemicals or power consumed, or, if the water supply is purchased, the saving is in dollars paid to the wholesaler. Deferment of the need for plant expansion saves capital expenditures, and is thus another type of saving.

Transmission mains and distribution systems need to be expanded or reinforced when their designed capacity is exceeded, so as to maintain adequate pressures and a satisfactory reserve capacity. Reservoirs, standpipes, and elevated tanks likewise may need to be expanded as consumption increases.

This report is intended to aid the water works industry in its efforts to evaluate and improve conservation practices. It furnishes the operator of the water works plant complete information on the items which must be considered in accounting for the water supplied to the distribution system. If a proper analysis is made, he then will be in a position to determine whether his plant is being operated at maximum efficiency; or if not, what steps he should take to improve conditions.

An audit of the water delivered to the system will provide a basis for comparison with other systems, and a method for evaluating the conservation procedures. The data used in the audit must be accurate and include metered delivery to the distribution system, metered sales, and metered ratio—that is, the ratio of metered sales to metered delivery.

Delivery and Sales

Total metered delivery to the distribution system preferably should be determined by a master meter installed on the mains supplying the system with treated water. This should not include use or waste at the filter plant, pump station, or supply works.

Total metered sales should be determined for the shortest period that is economically feasible, usually from 1 to 6 months, depending on the size of the system, dial capacity of meters, and billing procedures. The three principal types of sales are: [1] industrial and commercial, including water for irrigation; [2] domestic or residential; and [3] public use.

Industrial and commercial meters should be read monthly, whereas meters recording domestic or residential consumption should be read as often as feasible, and if not monthly, the readings should be adjusted to allow for seasonal variations in consumption, so that reasonably accurate comparisons can be made.

All public use should be metered, and readings made periodically whether or not a charge is made for the water used. This includes such items as use in schools and other publicly owned buildings, hospitals, and charitable institutions. Also included is use by public works agencies such as water, sewer, and street departments for con-

struction and operating programs, as well as fire department use and waste and park department use and waste.

If actual metered use is not feasible, as in fire fighting, the amount used should be estimated, based on the number and size of hose streams, pressure, and length of time used. Accurate records should be kept of all such use. Street department watering trucks, if not metered, should record the capacity of each tank and the number of tank loads used each day. If it is not possible to secure this information, no amount should be included in the metered sales. The omission can be indicated by a footnote when making reports, and for comparative purposes the amount of such unmetered use should not be estimated in excess of 1 per cent.

Metered Ratio

Determination of the metered ratio is the first step in evaluating performance. Good performance is generally indicated by a metered ratio of 85–90 per cent, where the use of water is between 100 and 125 gpcd. Where large industrial use causes a higher per capita use, the ratio may approach 100 per cent. The difference between the metered ratio and 100 per cent is unaccounted-for water. This may vary from 10 to 15 per cent in a well operated system where the consumption is between 100 and 125 gpcd.

The metered ratio will vary, depending on the type of system and other factors. The effect of these is usually obvious, and although much has been written about each one, they are described briefly below:

Age of system and ground conditions. In determining whether or not the metered ratio is satisfactory, the age of the system and ground conditions must

be considered. In an old system a large amount of unavoidable leakage must be expected, that is, the leakage which it would cost more to locate and repair than to permit to exist. The ground conditions should not influence the conclusion as to whether or not the plant is operating efficiently, but if they are such as to permit water to escape easily, involving presence of rock, gravel, or sand, the possibility of hidden underground losses is much greater, and if the unaccounted-for loss is too high, steps should immediately be taken to locate these losses.

Unavoidable leakage. This item can be described in general as the amount of underground losses in mains and services of the distribution system that would cost more to locate and repair than to permit to exist. The amount will vary from the allowable leakage cited in Section 13.7 of the Standard for Installation of Cast-Iron Water Mains (AWWA C600) in the test of a newly laid cast-iron pipeline—"70 US gal per 24 hours per mile of pipe per inch of nominal diameter for pipe in 12 ft lengths evaluated on a pressure basis of 150 psi." (1)—to 3,000 gpd per mile of main, a figure that has been determined by various formulas to be a reasonable value in an average eastern city distribution system. Experience has shown that the value may range from 1,000 to 3,000 gpd per mile of pipe, depending on the age of the system, ground conditions, type of pipe and services, type of community, pressures, and source of supply.

Pressures and source of supply. Pressures have a definite effect on the metered ratio, since the higher the pressures the greater the amount of avoidable and unavoidable waste. For example, outlets will discharge approximately 40 per cent more water under a

pressure of 100 psi than under that of 50 psi. High pressures also have a tendency to create more leaks by forcing calking in pipe joints and causing more rapid wear in the moving parts of water facilities. Therefore, a larger unaccounted-for figure is permissible where high pressures exist than under low pressure conditions.

Whether the supply is by gravity or pumps effects the necessity of reducing the unaccounted-for figure to a minimum. Obviously, if the supply is by gravity and plentiful, there is little or no production cost, except water treatment, and if the supply is ample, the incentive to take expensive means to maintain a high metered ratio is not great. If the supply is limited, however, everything possible should be done to conserve the available supply and put off the expense of building new reservoirs and laying pipelines for as long as possible. When the supply is pumped there is every incentive to reduce the unaccounted-for water to a minimum, as water then becomes a costly product and the daily operating cost can be reduced by the elimination of waste. Also, the need for plant expansion can be postponed.

Quality of materials and workmanship. These items can have a decided effect on the metered ratio, usually depending on whether or not the mains are laid by contract or by the employees of the water department or company, and also the quality of the specifications used and the inspection provided.

The proper type and weight of pipe should be used to meet local conditions, and valves, hydrants, and other special items should be of the best possible design and manufacture.

Use per capita and per mile of main. The per capita consumption is not con-

clusive evidence of the waste conditions in a system, and does not necessarily determine whether the metered ratio is satisfactory. In order to have any significance, the metered consumption should be divided among domestic, commercial, and industrial use. In developing a per capita figure, industrial used should be omitted, and if the remaining figure is higher than the average for comparable systems, the unaccounted-for water should be investigated even though the metered ratio seems to be reasonably high. The accuracy of per capita figures is dependent on census figures that are usually obtained once every 10 years, and figures for the intervening years may be greatly in error. The average use per customer can be computed more accurately at any time, and this method is recommended for use in the future for comparative purposes.

The use per mile of main is also an inconclusive figure, and should be analyzed carefully before being applied to the situation at hand. In industrial and thickly populated apartment house areas, the consumption per mile of main can be legitimately high, while in purely residential sections, the use per mile of main should be correspondingly low. In a residential community the allowable unavoidable leakage will constitute a substantial percentage of the unaccounted-for water, and, consequently, a comparatively low metered ratio is allowable. The converse is true in a system predominantly industrial and commercial.

Amount of industrial and commercial use. The amount of industrial and commercial use is probably the most important factor in determining whether or not the metered ratio is satisfactory. The type of city may

vary from a purely residential community to a heavily industrialized city where the use through meters of 2-in. and larger diameter may amount to as much as 75 per cent of the total consumption. In the former case, a metered ratio of 80 per cent may be satisfactory because of the low consumption per mile of main, and in the latter case even with a metered ratio of 90 per cent there may be much avoidable waste. The only dependable method of securing a metered ratio from which definite conclusions can be drawn is to eliminate the industrial use from all consideration.

Amount of underregistration and the unauthorized use. The actual underregistration of domestic meters in a system can vary from 2 per cent to as high as 15 per cent, depending on the local meter maintenance program. The majority of state public service commissions require private water companies and, in some states, municipal water departments, to remove domestic meters for replacement or repair at least once every 10 years. The optimum frequency of meter repairs is dependent on local conditions that may vary widely throughout the country, but an overall allowance for underregistration of 3 per cent should be economically feasible. Industrial meters should be tested in place under operating conditions, if possible, at least once a year, and with exceptionally large consumers a monthly test is desirable.

The unauthorized use of water sometimes proves to be an important factor in the case of a low-metered ratio. The most likely cause of unauthorized use is through an unmetered fire line, or, in rare cases, the deliberate bypassing of an industrial meter. One

method of controlling unauthorized use through fire lines is by the installation of detector-type meters, but this is not advisable if the service is used for both industrial purposes and fire protection. The best practice is to separate the fire line from the industrial service with the proper type of meter on the industrial service and a detector device on the first line.

Per Capita Loss

A second index of performance is the difference between the metered delivery and metered sales expressed in gallons per capita served per day, otherwise known as the per capita loss. Where the total delivery to the system is less than 80 gpcd, the per capita loss may have more significance. A loss of 10-12 gpcd may be satisfactory even though the metered ratio is lower than 85 per cent. In a similar way, the significance of losses per customer should also be studied and evaluated. If, after making allowances for the applicable variables in a table of accounted-for water, the ratio is not satisfactory, underground leakage or underregistration of meters is indicated.

Importance of Maintenance

Good maintenance will, in general, result in a high metered ratio and low unaccounted-for figure. A low ratio should not be accepted as indicative of good performance without proof that it cannot be improved. The major points to be included in a good maintenance program are:

1. *Definite program of meter testing and repair.* Accuracy of the master meters as well as industrial and domestic meters is essential. Domestic meters should be removed for testing and repair periodically, the period between

testing to be determined by experience in each system, and all commercial and industrial meters 2 in. and larger in diameter should be tested at least annually, in the field if possible.

2. *Definite program of leakage and waste control by comprehensive surveys.* The frequency of these investigations should be determined by changes in the metered ratio and the results obtained by the program.

3. *Complete records of operating procedures of all types.* The indexes of metered ratio and per capita loss will immediately reflect conditions needing correction.

4. *Periodic operation of valves and hydrants and proper maintenance if necessary.*

Unmetered Systems

For unmetered systems the methods of evaluating conservation practices cannot be so accurate. As in the case of the metered system, the amount of water supplied to the distribution system should be measured by master meters. Also the amount of water used by industrial and commercial accounts should be metered. In many unmetered systems some domestic accounts are metered either at the request of the consumer or in accordance with a policy of selective metering, whereby wasteful accounts are metered.

A table of accounted-for water can be prepared on the basis of the metered accounts and allowances for underregistration of meters, and for public uses as previously described. The domestic unmetered use can be estimated by using a figure of 60 gpcd, of which 50 gal is for actual use and 10 gal for uncontrolled leakage in the plumbing fixtures. A figure of 3,000 gpd per mile of main can be used for unavoidable

leakage. The amount of unaccounted-for water can then be determined by use of these factors, and will be valuable for purposes of comparing the efficiency of local operations from time to time. Other valuable standards are per capita consumption, consumption per customer, consumption per mile of main, and minimum night rate of consumption.

The amount of each of these may vary widely, and local conditions should be carefully considered when interpreting them or making comparisons with other systems.

Conclusion

Since this report is intended to present methods for evaluating conservation procedures and methods of improving performance, no attempt has been made to recommend specific techniques. Different techniques may be equally effective in obtaining a high metered ratio, and the results obtained

are of primary interest to this committee.

Many articles on this subject have been published in the JOURNAL, and lists of these can be found in the indexes (2-3). Recent articles are indexed yearly in the December issue. Other publications with articles of interest include *Public Works*, *Engineering News-Record*, *Water Works Engineering*, *The American City*, *Water and Sewage Works*, and *Journal of the New England Water Works Association*.

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Factors Limiting Financing of New Water Works Construction

—Alfred LeFeber—

A paper presented on Sep. 19, 1957, at the Ohio Section Meeting, Cincinnati, Ohio, by Alfred LeFeber, Cons. Engr., Cincinnati, Ohio.

FORTY years of experience have provided much information concerning construction costs, most of which were directly related to market conditions—for it is impossible to escape the consequences of the market and the implications of these consequences. Before the present period, the advance and decline of money costs, closely paralleling the so-called business cycle, has been a common phenomenon. At no time in that period was there a constant upward trend without much apparent reason, as there is at present. The upward trend referred to is that shown by the unit costs and the labor and material costs of water works construction. This trend is definitely tied to the inflationary spiral which most recognize but few understand.

For nearly 20 years the apparent cost of money was low and money was regarded as cheap. However, the cheap money cost was and is reflected in higher commodity costs so that any endeavor in the water works field is, like everything else, caught in the upward inflationary trend. This is not an attempt to explain inflation or to suggest a cure—if one is desirable—but is simply intended to direct attention to the factors which increase water costs today.

Housing Practice Factor

One of the contributing factors apparently completely overlooked is a trend manifested in present subdivision and housing development practices. Because of limited transportation and other considerations 40 or 50 years ago, the average residential property was a lot 50×120 ft. Many of the old installations were financed by general obligation bonds at interest rates ranging from 3 to 5 per cent. No attempt was made to employ other means of financing, largely because there was no market for other securities and because the quality of these other types of securities had not been established. With present constitutional tax limitations, ways have been sought to finance various types of public improvements by means other than general taxation, in order that improvements of general benefit in an intangible sense could be financed by general taxation. The search resulted in the development of the revenue bond which is based upon rates adequate to service self-liquidating public facilities.

Increase in Materials

As the newer trends in subdividing and home building have progressed, the water works industry has found that the quantities of material necessary to

serve a single residence have increased 50-100 per cent. This increase is expressed in dollars and in terms of physical items necessary to accomplish a construction goal. Thus, if, years ago, 50 ft of pipe were required to service a residential lot, 75-100 ft are now required to service a single residential unit. Where, years ago, the financing was guaranteed by general taxes, the security buyer felt that no additional protection was necessary. Today, because of early abuse in the field of revenue financing, security buyers insist upon reserve or coverage to the extent of 50 per cent above average or, in some cases, maximum annual debt service. This, of course, is immediately reflected in rates to be charged for the commodity—when cost is not broken up into a number of categories such as general taxation, special assessments, and water service. Today, the average water bill in communities where water facilities are financed by revenue bonds reflects not only the cost of the commodity but the debt service and reserve or coverage as well.

Investor Reluctance

The difficulty in marketing securities involving high rates arises from the fact that many water systems, based upon smaller lots and general taxation, reflected rates sufficient to defray operating costs only. A few short years ago, \$1 per month was considered an ample charge for water service at the minimum level. Security buyers are hesitant to purchase securities where the monthly cost for minimum service will be as high as \$7-\$9 and where it will sometimes reflect 40-year debt retirement. It has been an extremely

difficult task to educate the security consumer in order to encourage purchase of securities. Of considerable importance in this respect is the differentiation between real-estate developments and bona fide customers.

As a result of prior unhappy experiences, the security buyer will not invest in speculative real-estate developments. This means that in order to finance entirely new construction, guarantees must be arranged to satisfy the security buyer that there will be an adequate number of customers at a given rate to satisfy the investment and all of the indenture requirements. In recent years engineers have been compelled to perfect contractual and other arrangements by which progress can be made. In many instances, a chicken-or-the-egg situation exists, where federal underwriting of houses and, consequently, water consumers is held up pending the guarantee of public water supply and sanitary-sewer facilities. These facilities cannot be financed without the houses. The houses will not be financed without the facilities, and so it goes.

Conclusion

A means must be devised whereby the circle is broken and the project can go forward. This can be accomplished on almost any scale, but will require much paper work and complete disclosure of all the facts so that the developer will be aware of his part, the potential homeowner will know what his minimum monthly water expense will be, and the security buyer can be informed of all factors necessary to elicit his investment.

1957 Conference—Atlantic City

THE first 3,000 registration was the headline news of AWWA's 77th Annual Conference, held last May 12-17 at Atlantic City, N.J., but even more memorable to the 3,067 who were on hand was the biggest and best program of technical sessions, exhibits, social functions, and other features ever scheduled. The rapid growth of the Association's meetings, both in attendance—which has risen 50 per cent in the past 3 years—and in outlook, is a direct reflection not only of the growth of AWWA itself, but of the growth of interest in water. And through the week, there was no question that water was in its element at Convention Hall, at the eight hotels that provided housing, and throughout the resort city and its many famous restaurants.

Host-in-Chief and Arranger Extraordinary for this record crowd, as chairman of the Convention Management Committee, was J. Leslie Hart, whose task was shared with:

Representing AWWA

CHARLES J. ALFKE
LEWIS W. KLOCKNER JR.

Representing WSWMA

LOUIS F. FRAZZA
THOMAS T. QUIGLEY

Ex Officio

PAUL WEIR, *President*
HARRY E. JORDAN, *Secretary*
E. SHAW COLE, *Chm., Publication Com.*

HARRY E. SCHLENZ, *President*
JOHN G. STEWART, *Manager*

Helping to make even the business of the meeting a pleasure, Shaw Cole's Publication Committee set up fifteen technical sessions that ran the gamut of present problems. Featured by discussions of saline-water conversion, reservoir evaporation control, cloud seeding, water resources development—including an address by New Jersey's Governor Meyner—fluoride application, and water utility earnings, the program drew record audiences and record enthusiasm. A complete list of the papers presented appears on pages 1602-04. Those that have already been published in the JOURNAL may be located by reference to the annual index (pages 1619-37).

A pleasure that was really mouth-watering, too, was provided by 101 of AWWA's Associate Members, who covered 20,000 sq ft of the Atlantic City Auditorium with the kind of equipment and materials that every water utility man wanted to take home. To John Stewart and his Exhibit Committee, the 197 boothsful of exhibits represented a new peak not only in quantity, but in quality as well, providing a strong complement to the rest of the technical program.

And finally, through the efforts of Lew Klockner, Hubert O'Brien, Harvey Howe, Sid Wilson, Bill Reinicker, and Harold Ohland, the planned pleasure was more than a pleasure from the Boardwalk Buffet that started the fun on

Henshaw Cup		Hill Cup		Old Oaken Bucket	
Cuban	84.6%	Indiana	48.37	California	1,349
Rocky Mountain ..	82.9%	Iowa	24.44	Southwest	1,058
Montana	64.8%	Nebraska	23.55	New York	834

Sunday night right through the last dance of the Thursday ball. On Monday night, the Rutgers Glee Club helped the officers and awardees do the honors at a reception and dance. On Tuesday, Ray Middleton and a troupe of Broadway music makers enthralled everyone with a program of Victor Herbert, Stephen Foster, and Sigmund Romberg. A golf tournament on Tuesday and Wednesday evening free to discover the delights of Atlantic City helped build up the week's enjoyment to its climax in the Annual Dinner & Dance that this year paid tribute to William Whitlock Brush for his 35 years as an AWWA officer. That the 1,200 on hand to honor Bill Brush and to welcome Fred Merryfield into presidency included eighteen of AWWA's past-presidents helped make the affair still more memorable.

To get everyone there and back home again, Lou Frazza and his Transportation Committee catered to a record in travel needs, and catering to a record in other requirements was the whole New Jersey Section as well as many of its Pennsylvania Section friends. Meanwhile, the ladies were taking care of themselves in record numbers too—in numbers present as well as number of things to do. It was Louise (Mrs. Karl) Mann and her distaff staff, headed by Missuses F. G. Merckel, C. G. Bourgin, P. S. Wilson, and J. A. Frank, who made the whole week a party for water wives.

Association Awards

Honorary Membership was conferred upon Albert E. Berry, Charles H. Capen, S. Logan Kerr, and Willibald A. Kunigk. The citations follow:

ALBERT EDWARD BERRY, General Manager & Chief Engineer, Ontario Water Resources Commission: *member of the Association since 1920; Life Member 1950; President 1952; Director for the Canadian Section 1937-40; Fuller Award 1938; Goodell Prize 1950; one who is devoted to the advancement of engineered sanitation and whose leadership has been recognized by the Canadian members whom he has served for more than twenty-five years as Secretary; a gracious gentleman.*

CHARLES HERBERT CAPEN, Consulting Engineer; retired Chief Engineer of North Jersey District Water Supply Commission: *member of the Association since 1930; President 1953; Director for the New Jersey Section 1947-50; Chairman of the Publication Committee 1947-51; Fuller Award 1938; one who has served competently and conscientiously in important engineering projects of great value to the users of the service provided.*

SAMUEL LOGAN KERR, Consulting Engineer, S. Logan Kerr & Company, Inc., Flourtown, Pa.: *member of the Association since 1935; one who is internationally recognized for his superior competence in the field of hydromechanics; ever willing to serve in widening the general understanding of difficult hydraulic problems.*

WILLIBALD ALPHONS KUNIGK, Retired Superintendent & Chief Engineer of the Water Division, City of Tacoma, Wash.: *member of the Association since 1924; Life Member 1954; Director for the Pacific Northwest Section 1930-32; of foreign birth, imbued with the true pioneer spirit of the Northwest, self-educated, devoted to the advancement of sound engineering and service to his neighbors, a personality highly esteemed throughout the Pacific Northwest, whose competence as an engineer has been widely recognized by professional societies.*

The John M. Diven Medal, awarded to the member whose services to the water works field during the preceding year are deemed most outstanding, was presented to John H. Murdoch Jr. The citation follows:

JOHN HUEY MURDOCH JR., Consultant (recently retired Vice-President and Counsel) American Water Works Service Company: *for his many contributions to the water works industry manifested by his provocative discussions of industry problems; his articulate presentations to the membership have stimulated thinking along constructive lines.*

The John M. Goodell Prize, granted for the best paper published in the JOURNAL from October 1955 through September 1956, was conferred upon Thurston E. Larson. The citation follows:

THURSTON E. LARSON, Acting Chief, Illinois State Water Survey: *for his paper entitled "Report on Loss in Carrying Capacity of Water Mains" as published in the November 1955 issue of the Journal (Vol. 47, page 1061). Dr. Larson's paper deals in a scholarly way with one of the most important problems in the entire water works industry and has high value to both the technology and the literature of the field.*

Division Awards, granted for the best JOURNAL paper (October 1955-September 1956) in the field of interest of each of the four AWWA Divisions, were presented to Jack W. MacKay, Louis R. Howson, John R. Baylis, and Warren J. Kaufman and Gerald T. Orlob. The citations follow:

Distribution Division Award: JACK WHITING MACKAY, Vice-President-Sales, American Cast Iron Pipe Company, Birmingham, Ala.: *for his paper entitled "Development and Use of Specifications for Cast-Iron Pressure Pipe and Fittings." This paper, published in the July 1956 issue of the Journal (Vol. 48, page 863), records an understandable analysis of a series of standards of great importance to the water supply field.*

Management Division Award: LOUIS RICHARD HOWSON, Consulting Engineer, Alvord, Burdick & Howson, Chicago, Ill.: *for his paper entitled "Rates, Revenues, and Rising Costs." This paper, published in the May 1956 issue of the Journal (Vol. 48, page 465), is another demonstration of the author's capacity to think clearly and express himself convincingly upon the basic problems of our industry.*

Purification Division Award: JOHN ROBERT BAYLIS, Engineer of Water Purification, Department of Water and Sewers, Chicago, Ill.; *for his paper entitled "Seven Years of High-Rate Filtration."* This paper, published in the May 1956 issue of the *Journal* (Vol. 48, page 585), has great value in its demonstration of the propriety of revising certain long-held criteria in water treatment.

Resources Division Award: WARREN JOHN KAUFMAN, Professor of Sanitary Engineering, and GERALD THORVALD ORLOB, Assistant Professor of Civil Engineering, both of the University of California, Berkeley, Calif.: *for their paper entitled "Measuring Ground Water Movement With Radioactive and Chemical Tracers."* This paper was published in the May 1956 issue of the *Journal* (Vol. 48, page 559). Its great value lies in its critical analysis of the merits and deficiencies of the procedures studied. A forward looking study of an important problem.

The Harry E. Jordan Scholarship Award, granted to further the education of deserving applicants from the East (a different region is selected each year), was conferred upon HERBERT H. HASSIS, senior in civil engineering at Clarkson College, Potsdam, N.Y., and WILBERT H. SCHLIMMEYER, graduate student in sanitary engineering at Rutgers University, New Brunswick, N.J.

The George Warren Fuller Awards were presented to 25 men whose Sections had nominated them in the year beginning with the 1956 Annual Conference at St. Louis and ending with the opening of the 1957 Conference at Atlantic City. The awards—which are conferred for "distinguished service in the water supply field and in commemoration of the sound engineering skill, the brilliant diplomatic talent, and the constructive leadership of men in the Association which characterized the life of George Warren Fuller"—went to the following men:

Alabama-Mississippi Section—JESSE LEE HALEY: *for his untiring efforts in the establishment and conduct of the Mississippi water works operators short course; for his deep interest in the success of the Section; and for his long years of unselfish service to his community.*

Arizona Section—ROBERT MILNER CUSHING: *for his service as secretary and chairman of the Arizona Section; for his committee work; and for his many years of faithful and effective service to his state and his profession through his constructive leadership and engineering skill.*

California Section—WILLIAM CHARLES WELMON: *for his work as chairman of the committee which developed the "Rules and Standards for Design and Construction of Water Systems" adopted by the California Public Utilities Commission; and for his leadership in the formation of the Section's Business Management Division.*

Canadian Section—ANTOINE VALENTINE DELAPORTE: *for a distinguished contribution to the public service of the province of Ontario, directed to maximum*

utilization of laboratory investigations, to far-reaching research programs, and to new developments in water purification processes and in related fields of sanitation.

Chesapeake Section—EZRA BAILEY WHITMAN: in recognition of his distinguished service as a public official and practicing engineer; his active and continuing participation in the affairs of the Section since its organization; and his interest in the training and development of younger engineers.

Cuban Section—LEANDRO DE GOICOECHEA: for his complete dedication to and constant work for the benefit of the Section, as well as for his valuable work related to problems of hydraulics and sanitary engineering in Cuba.

Florida Section—WYLIE WEEDEN GILLESPIE: in recognition of his outstanding leadership in the water works field; his sound engineering talents; brilliant and diplomatic approach; and his services to the Florida Section, particularly as chairman and director.

Illinois Section—HORACE RAYMOND FRYE: for his capable direction of the expansion of his city's water system; his many years of leadership and service to the Section; and his ten years of pioneering study of the fluoridation of his city's water supply, the first installation in Illinois.

Indiana Section—MARSHALL PAYNE CRABILL: in recognition of his contributions to and continuing interest in sound operating procedures; his unstinting services to the Association and the Section; and his qualities of leadership and understanding which have so benefited the employees under his supervision.

Iowa Section—THOMAS WESLEY THORPE: for his many years of devoted service to the AWWA, to the old Missouri Valley Section, and to the Iowa Section; and for the generous sharing of his competency in the development of water supplies within his own and neighboring states.

Kansas Section—RUSSELL LOUIS CULP: for his study of Kansas water problems; for his contribution to improved water works practice through Association committees and the water works school; and for his engineering ability, genuine modesty, and sound leadership.

Kentucky-Tennessee Section—JULIAN ROANE FLEMING: for his helpful assistance to the water works operators in Tennessee; for his many valuable contributions to their training in the water works operators schools; and for his loyalty and services to the Kentucky-Tennessee Section.

Michigan Section—ROBERT LETTS MCNAMEE: in recognition of his outstanding contributions in water supply engineering, including filtration practice and distribution system design; and his constructive participation in committees of the Section.

Missouri Section—ELLSWORTH LINCOLN FILBY: for sincere devotion to the profession of sanitary engineering; for outstanding achievement in the affairs of the Association at the national level; and for helpful guidance in matters of policy and the activities of the Missouri Section.

New England Section—ARTHUR D. WESTON: for his inspiring leadership in the development and protection of water resources; his continuing interest in re-

search; his broad vision and good judgment in the evolution of water policy; and his patience in counseling young engineers and water works officials.

New Jersey Section—GEORGE DUSENBURY NORCOM: for his many years of service to the water works profession as a chemist and sanitary engineer; his services to the Section as an officer and director; and for his contributions to the science of water purification.

New York Section—REEVES NEWSOM: for devotion to the betterment of the entire water works field through his activities at both Section and Association levels; for the respect engendered for himself and his chosen profession in his services as the Association's president, as consulting engineer, and as village manager.

North Carolina Section—WILLIAM WITTY ADKINS: for his untiring efforts and activity in the water works operators school; and in recognition of his services to the Section as chairman, vice-chairman, and trustee.

Ohio Section—CHARLES EDWIN BEATTY: in recognition of his leadership and services to the Ohio Section, particularly as director; for his untiring efforts to promote district activities within the Section; and for his continuing loyalty and services to the water profession.

Pacific Northwest Section—ARTHUR STANLEY GORDON MUSGRAVE: for distinguished service in the water supply field; loyal devotion to the Section's welfare; and, in all the Association's undertakings, the unselfish gift of himself, which characterized the life of George Warren Fuller.

Pennsylvania Section—JOHN HUEY MURDOCH JR.: for his long and distinguished service to the Association and to the water works industry, in management, operation, and civil defense, particularly concerned with the legal aspects and the responsibility incumbent upon all engaged in endeavors so vital to the public health and welfare.

Southeastern Section—WILLIAM THOMAS LINTON: in recognition of his outstanding service to the water works field as state sanitary engineer for South Carolina; director of the state water pollution control authority; former secretary of the Section; and former secretary of the state water and sewage association.

Southwest Section—J. RICHARD PIERCE: for his active participation and leadership in the affairs of the Southwest Section; for his services as Section director; and for his professional and civic endeavors in the advancement of the water works profession in his community and his state.

Virginia Section—WILLIAM RAY ODOR: in recognition of his successful efforts to maintain the high standards of the social and technical programs of the Virginia Section; and for his excellent representation of Virginia water works men at the annual meetings of the Association.

Wisconsin Section—JAMES EARL KERSLAKE: for the work to which he devoted countless hours over a period of twenty-six years as committee member and chairman in the preparation of standard specifications for nineteen chemicals used by the water supply industry; and for his untiring efforts toward the success of the Section's meetings and activities.

Schedule of Conference Papers and Reports

MONDAY MORNING, May 13

Water Resources Division

- Land Policy for Impounding Reservoirs.....Francis S. Friel
 Discussion.....E. S. Chase & H. J. Graesser
 Public Access to Lands Surrounding Impounding Reservoirs.....
 Daniel P. Morse, E. Jerry Allen & John W. MacFarland

Water Works Administration Committee—Open Session

- Progress Reports of Committees
 Joint Administration of Water and Sewage Facilities....L. N. Thompson & R. J. McLeod
 Water Main Extension Policy.....L. S. Finch
 Revenue-producing Water.....E. Shaw Cole
 Rating Scale for Water Works.....John H. Murdoch Jr.
 Safety Practices.....R. J. Faust
 In-Service Training.....R. J. Faust
 Publicity Program.....E. L. Filby
 Air Conditioning.....E. L. Bean

MONDAY AFTERNOON, May 13

Water Distribution Division

- Underground Arteries, 1956—Motion Picture.....Johns-Manville Sales Corp.
 Applications of Automation—Panel Discussion
 Philadelphia Water System.....V. A. Appleyard
 Long Island Water Company.....S. C. McLendon
 Solution Effects of Water Upon Cement and Concrete Linings of Water Mains.....
 Martin E. Flentje & Robert J. Sweitzer
 Water Hammer Allowances in Pipe Design.....S. Logan Kerr
 Discussion.....Vance C. Lischer, Fred G. Gordon & B. E. Payne
 The Courts Consider Pipeline Breaks.....John H. Murdoch Jr.

Water Resources Division

- Saline Water Conversion.....David Jenkins
 Discussion.....S. T. Powell
 Reservoir Evaporation Control.....Lloyd O. Timblin Jr., W. T. Moran & W. W. Garstka
 Weather Modification—Task Group Report.....Burton S. Grant
 Honolulu Water Supply.....Edward J. Morgan

TUESDAY MORNING, May 14

Water Works Practice Committee—Open Session

- Progress Reports of Committees
 Butterfly Valves.....Fred G. Gordon
 Gate Valves.....David Auld & L. E. Tabor
 Meters.....James G. Carns
 Progress in Standardization of Water Pipe
 Cast-Iron Pipe.....Thomas H. Wigginn
 Steel Pipe.....H. Arthur Price
 Reinforced Concrete Pipe.....E. W. Whitlock
 Joint Committee on Spillway Design.....Thomas H. Wigginn

Water Purification Division

- The Jar Test—A Review.....A. P. Black
Coagulant Aids.....J. M. Cohen
Radioactive Culture Media.....Gilbert V. Levin, Venton R. Harrison & Walter C. Hess
Automation and Remote Control of Chemical Feeders.....Paul Coffman
Organic Components in Water Causing Taste and Odor.....F. M. Middleton

TUESDAY AFTERNOON, May 14**Water Resources Policy and Development—General Session**

- The Oregon Water Law.....Fred Merryfield
New Jersey Water Supply Development.....Governor Robert B. Meyner,
W. H. Baumer & Charles H. Capen
Planning—Key to Greater Utilization of Water Resources.....M. J. Shelton

WEDNESDAY MORNING, May 15**General Session**

- AWWA Specifications and the Certification Program.....Frank C. Amsbary Jr.
Proposed Amendments to the Constitution.....Harry E. Jordan
National Water Policy.....Abel Wolman
Water Works Planning in Great Britain.....G. M. Binnie
Panel Discussion—Highway Relocation Problems.....Led by H. B. Shaw,
E. Jerry Allen, S. S. Anthony, J. J. Barr, E. A. Bell,
E. W. Clark, Thomas W. Moses & A. R. Vollmer

WEDNESDAY AFTERNOON, May 15**Water Resources Division**

- Water—Wealth or Worry for America—Motion Picture....Cast Iron Pipe Research Assn.
Progress Reports of Committees
Underground Waste Disposal and Control.....Lynn M. Miller
Artificial Ground Water Recharge.....John J. Baffa

Water Works Management Division

- Progress Reports of Committees
Radio and Mobile Communications Facilities.....M. B. Cunningham
Water Use in Fire Prevention and Protection.....A. A. Ulrich
Compensation of Water Works Personnel.....Garvin H. Dyer
Pension and Retirement Plans.....John G. Copley
Job Classifications.....Robert S. Millar
Water Use.....H. E. Hudson Jr.

Water Distribution Division

- Greater Than Gold—Motion Picture.....Koppers Co., Inc.
Progress Reports of Committees
Effect of Purification Methods on Water Main Carrying Capacity.....T. E. Larson
Protective Coatings for Water Distribution Systems.....R. F. McCauley
Oil-Line River Crossings.....M. B. Cunningham
Reinforced Concrete Pipe.....E. W. Whitlock

Water Purification Division

- Progress Reports of Committees
Studies of Chromium and Cadmium Solubility and Toxicity.....R. D. MacKenzie
Research on Water Coagulation.....A. P. Black

Manganese Deposition in Pipelines.....	A. E. Griffin
Specifications for Liquid Chlorine.....	H. A. Faber
Specifications and Tests for Water Purification Chemicals.....	James E. Kerslake
Specifications for Fluorides.....	Oscar Gullans
Backflow Preventers.....	A. T. Dempster
Standard Methods for the Examination of Water, Sewage, and Industrial Wastes.....	Michael J. Taras
Uniformity of Methods of Water Examination.....	Michael J. Taras
Effects of Synthetic Detergents on Water Supplies.....	Paul D. Haney
Analytical Methods for Detergents.....	James C. Vaughn
Water Conditioning and Prevention of Corrosion.....	Rolf Eliassen

THURSDAY MORNING, May 16

Water Distribution Division

Lifelines for Civilization—Motion Picture.....	American Concrete Pressure Pipe Assn.
Service Buildings.....	L. S. Finch
Service Trucks.....	Fred D. Jones
Panel Discussion—Setting Meters.....	Led by W. Victor Weir, G. E. Arnold, James G. Carns, W. E. MacDonald & Marsden Smith
Panel Discussion—Cleaning and Relining Small Mains.....	R. W. Fitzgerald, Frank Schwenler & Lewis B. Smith

Water Purification Division

Handling Liquid Alum.....	James E. Kerslake
Discussion.....	Oscar Gullans, Norman E. Jackson, Leo Louis, David Lurie & Richard Ockershausen
Carbonation of Water-softening Sludge.....	F. A. Eidsness
Discussion.....	F. G. Nelson
Panel Discussion—Experiences in Applying Fluorides.....	Led by John R. Baylis, A. A. Bailey, E. L. Bean, A. P. Black, Marshall P. Crabill, A. E. Griffin, James E. Kerslake, J. W. Krasauskas, H. C. Medbery, B. C. Nesin, R. S. Phillips, J. C. Smith & J. C. Zufelt

THURSDAY AFTERNOON, May 16

Management Division—General Session

The 1957 Bond Market.....	George I. McKelvey
Problems in Personnel Recruiting.....	Milton Rosen
Wisconsin's Policy on Municipal Utility Taxation.....	A. P. Kuranz
Panel Discussion—Water Utility Earnings.....	Led by L. R. Howson, Burton S. Grant, M. H. McGuire, E. M. Hawkins Jr., H. J. Graeser, Claud R. Erickson, M. B. Whitaker & Fred Merryfield

Papers Scheduled at 1957 Section Meetings

THERE follows a summary listing of papers scheduled for presentation at 1957 Section Meetings. The dates of the Section Meetings from 1953 to 1957 and the locations for 1957 are listed on page 1617. Section officers who were elected at meetings held during 1957 are listed on page 2 P&R in the front of this issue. The programs are listed alphabetically by Sections, without regard to the date of presentation.

Alabama-Mississippi Section—October 20-23, 1957

Address of Welcome.....	Mayor Laz Quave
Report from AWWA.....	Lewis S. Finch
Public Relations From a Cashier's Viewpoint.....	Francis P. Scott
Weather Modifications in Theory and Practice.....	Irvin P. Krick
Panel Discussion—Water for Our Growing Cities.....	Led by Phillip E. LaMoreaux, Melvin Williams & Walter B. Jones
Mississippi Water Rights Law.....	Jack Pepper
Management of Municipal Utility Revenues.....	Gerald R. Carter
Some Aspects of Providing Domestic and Fire Protection Service to Small Communities...	C. M. McConaghy
Report of Safety in Water Works Operation.....	Karl A. Woltersdorf

Arizona Section—April 4-6, 1957

Address of Welcome.....	Mayor Richard G. Johnson
Use of Sewage Effluent in Agriculture.....	Albert Oshrin & Neal Dye
Discussion.....	Dario Travaini
Chlorinator Control Apparatus.....	Bruce Hedrick
Sand Trouble in Wells, Pumps, Tanks, and Mains—What Can Be Done About It?.....	Phil J. Martin Jr.
Comparison of Sewage Treatment Methods.....	H. W. Gillard
Stream of Life.....	Howard E. Lyman
Variation of Water Quality in Arizona.....	George Marx
Engineers' Dreams Are All Wet.....	Emil Krall
Maricopa County Requirements for Backfill.....	Cecil Overstreet
Discussion.....	Roy Hilbrant & John Rauscher
Demonstration of Pipe Joints.....	George Bogs, A. W. Miller & R. J. McLean
Water Production From Watersheds.....	George Barr
Possible Underground Water Supply in Northern Arizona.....	J. Joseph Perkins
Discussion.....	Sam Turner
Types of Liquid Level Control.....	R. M. Cushing
Accounting and Collecting Procedures.....	E. J. Umbenhauer
Panel Discussion—Sewer Maintenance	
Effect of Garbage Grinders on Sewers.....	Kenneth Scharman
This Problem—Industrial Waste.....	Arthur Pickett
Photographic Inspection of Underground Structures.....	A. A. Appel

California Section—Regional Meeting—April 26, 1957

Address of Welcome.....	Mayor Russell Hart
Response.....	M. J. Shelton
Water for California's Growing Cities.....	Max Bookman
Fundamentals of Corrosion in Water Utilities.....	F. O. Waters
California Cooperative Snow Surveys.....	Charles A. McCullough
Panel Discussion.....	Led by Gerald Jones
Construction Equipment for Small Water Utilities.....	W. K. Foerster
Office and Field Paper Forms.....	Caspar L. Winiger
Regulatory Problems of Privately-owned Water Utilities.....	John D. Reader
Sanitary Problems and Their Solution.....	Carl B. Johnston
Administrative Practices for Small Water Companies.....	Patrick J. Maloney

California Section—October 30–November 1, 1957

The Attorney's Part in Multipurpose Water Development.....	Porter A. Towner
Supplemental Water Supply for the San Francisco Bay Area.....	William L. Berry
Conversion of Saline Water.....	Everett D. Howe
Water Supply in Santa Clara County.....	Mark E. Thomas
Techniques of Cable Tool Drilling vs Rotary Drilling.....	Roscoe Moss Jr.
A Rotary Drilled Well for the City of Long Beach.....	Frank T. Higgins
Well Photography—In Respect to Repair and Rehabilitation.....	C. H. Sorter
Well, an Engineered Structure or a Hole in the Ground.....	S. T. Guardino
Reconnaissance of Owens River Aqueduct Watershed.....	Fred A. Camp
Industrial Safety Regulations for Vehicles.....	V. L. White
Use of Red Lights on Public Utility Vehicles.....	Seth K. Martin
Service Laterals—Repair or Renew.....	William H. Eppinger
Water Works Material—Your Money's Worth.....	Ray W. Jones
Pipe Jointing and Pipe Joint Leaks.....	O. A. Goldman
Water Use During Construction—Problems and Solutions.....	W. K. Foerster, John W. McBride, Carlyle Washburn & Frank W. Callahan
Gunite—Its Use in Reservoir Construction.....	Russell Kenmir
Variable Speed Motor Applications.....	
The Economics of Meter Maintenance Programs.....	P. M. Robinson
Design of Water Rate Structure.....	Walter J. Cavagnaro
Financial Diagnosis for the Small Water Company.....	Allen D. Harper
Electronics and Public Utilities.....	Frank Twohy
Actinomycetes in Water Supplies.....	Kent Bartholomew
Consideration of Toxicity in Respect to Drinking Water Supplies.....	Herbert E. Stokinger
Water Quality From the Soil and Plant Relationship Viewpoint.....	L. V. Wilcox
Removal of High Concentrations of Hydrogen Sulfide From Water Supplies.....	James Foxworthy
Air-Conditioning Water Use Regulations.....	Ralph M. Westcott

Canadian Section—June 17–19, 1957

General Water Works Problems—Guided Discussion.....	Led by W. D. Hurst
Design and Construction of Long Water Supply Lines.....	Louis R. Howson
Pipeline From Buffalo Pond Lake to Regina.....	A. Shattuck
Aids for Water Coagulation.....	A. E. Griffin & R. J. Baker
Distribution System Design.....	Lucien L'Allier
Distribution System Operation and Maintenance.....	K. E. Patrick

Microstraining and Its Applications in Water Clarification.....	P. L. Boucher
Water Works Emergency Committee Progress Report.....	D. B. Williams
Civil Defense Demonstration.....	C. D. Greater
Questions and Answers.....	A. E. Berry
Experience in Metropolitan Water Works Administration at Winnipeg.....	N. S. Bubbis
Some Aspects of Water Storage Reservoirs.....	A. B. Patterson
A Survey of Water Purification Practice in Canada.....	D. H. Matheson
Questions and Answers.....	A. E. Berry

Canadian Section—Maritime Branch—October 17-18, 1957

Microstraining in Water Clarification.....	P. L. Boucher
Panel Discussion—General Water Works Problems.....	Led by F. R. Fraser
Fluoridation—Its Control and Headaches.....	G. L. Renner
Guided Discussion—Management and Other Desk Problems.....	Led by J. W. Churchill
Metropolitan Organization for Essential Services.....	W. E. Moseley
Advantages of Metro Planning and Organization.....	J. F. MacLaren
Halifax-Metro Organization and Services.....	G. T. G. Scott
Administration and Operation of Metro.....	J. R. Kaye

Chesapeake Section—October 30–November 1, 1957

Address of Welcome.....	Alvin C. Welling
Potomac River Basin Studies.....	Byron Bird & Edwin E. Pyatt
Development of Proposed Water Resources Legislation in Delaware....	George M. Worriow
Research in Water Supply and Pollution Control.....	Harry Faber
Use of Coordinated Daily Laboratory Tests.....	Edward Scott Hopkins
Anne Arundel County's Problems.....	Paul L. Holland
Political Unification of Great Centers of Population.....	Gerald W. Johnson
Establishing Fair Value in Water Rate Cases.....	Charles H. Kessler & Hugh H. Hunter
Conversion of a Reserve Raw-Water Tunnel for Distribution Purposes.....	John C. Geyer
Progress Report on the Specialty Board on Certification of Sanitary Engineers.....	Mark D. Hollis
Federal Inter-Agencies Activities Involved in Water Supply.....	M. Le Bosquet Jr.
McIlroy Analyzer Experiences.....	E. E. Bolls Jr., M. Joseph Willis & Jerome B. Wolff
Algae and Other Interference Organisms in the Chesapeake Bay Area.....	C. M. Palmer
Irrigation Use of Water.....	Luther B. Bohanan
Simplified Fluoride Distillation Method.....	Ervin Bellack

Florida Section—November 10-13, 1957

Address of Welcome.....	Mayor Haydon Burns
Response.....	Stanley Sweeney
The Challenge to Our Organizations.....	Emil C. Jensen
Penny-Wise Water.....	Lewis S. Finch
Selling Our Services to the Public.....	Morris M. Cohn
Lifelines for Civilizations—Motion Picture	
Panel Discussion—Disposal of Softening Plant Sludge.....	Led by Fred A. Eidsness, David B. Preston, C. S. McKinney & E. C. Shreve Jr.
Hindered Settling in an Upflow Basin.....	J. D. Walker
Panel Discussion—Interpretation of Water Plant Analyses.....	Led by S. W. Wells, Charles P. Roddy, Frank S. Little & Roy Heasley
Monitoring for Radioactive Fallout.....	Harry P. Kramer

Florida's Water Resources Law.....	John W. Wakefield
Effect of Sewage and Industrial Wastes on Water Quality and Treatment.....	E. Sherman Chase
Pollution Study of Biscayne Bay.....	J. Neeland McNulty & Walter R. Lynn

Illinois Section—March 20-22, 1957

Address of Welcome.....	James W. Jardine
Impact of Water Use for Air Conditioning on Chicago Water Systems.....	H. H. Gerstein
Coliform Removal by Water Treatment Processes.....	Graham Walton
Public Relations Problems for Water Works Employees.....	Bert Johnson
University Cooperation.....	J. C. Dietz
Panel Discussion—Ground Water	
Construction and Maintenance of Rock Wells.....	E. L. Nordness
Construction and Maintenance of Gravel Wells.....	Albert Sabo
Water Well Production in Illinois.....	Robert T. Sasman
Application of Submersible Pumps for Deep Wells.....	E. R. Warnicke
Designing for Future Water Demands.....	A. H. Gent
Panel Discussion—Surface Waters	
Development and Control of Impounded Water Supplies.....	J. R. Gardner
Installation of Bascule Gates for Water Supply.....	H. L. Chastain
Mineral Quality of Illinois Rivers.....	T. E. Larson & Bernt O. Larson
Application of Electronics in Water Supply.....	Howard Jacoby
Oxidation-Reduction Potential Measurements.....	C. E. Margrave & James G. Weart
Breakdown Tests of Water Meters at Springfield.....	L. W. Hagel
Installation and Maintenance of Valves and Hydrants.....	L. F. Lindeen

Indiana Section—February 6-8, 1957

Address of Welcome.....	C. Everitt Robbins
Selection and Application of Centrifugal Pumps for the Water Works Industry.....	Richard Kummer
Municipal Softening and Iron and Manganese Removal.....	Eskel Nordell
Practical Aspects of Polyphosphate Treatment of Municipal Water Supplies.....	Herman A. Reda
Panel Discussion—All the Water You Want, When and Where You Want It?.....	Led by Lewis S. Finch
Can the Water Supply Industry Meet the Requirements of Today and Tomorrow?.....	H. E. Jordan
Trends in the Demand for Water in Indiana.....	B. A. Poole
What Seasonal or Peak Loads Should a Water Utility Be Expected to Meet?.....	H. H. Gerstein
Controlling Seasonal or Peak Loads by Demand Meters and Charges, or by Use Restrictions.....	M. P. Hatcher
Development of a Master Plan to Meet Future Water Needs.....	L. H. Enslow
Our Approach to a Master Plan	
Fort Wayne, Ind.	H. A. Kerby
Michigan City, Ind.	H. J. Draves
Rockport or Newport, Ind.	Donald Porter
Mishawaka, Ind.	Austin Klein

Iowa Section—October 16-18, 1957

Address of Welcome.....	A. B. Chambers
Response.....	P. F. Morgan

Operating Under A Union Contract.....	Jack F. Culley
Missouri River Water Quality as Affected by Upstream Storage.....	M. E. Rew & Joseph F. Erdei
Industrial Development and Local Utilities.....	T. E. Davidson II
Modern Customer Billing and Collecting Procedures and Equipment in Action.....	Don L. Bragg, John W. Prather, Robert L. Mason, & R. G. Carter
Radioactivity in Public Water Supplies.....	R. L. Morris
Drought Effect on Impounded Supplies.....	Jack Cleasby
Recent Developments in Research and Use of Coagulation Aids.....	Jesse M. Cohen
Committee Reports—Water Rates, Main Extensions, Job Classifications.....	Led by Mark Driftmier, G. C. Ahrens, D. Y. Caldwell, Marcus P. Powell & H. F. Seidel
Penny-Wise Water.....	Lewis S. Finch
Iowa's New Water Law.....	R. G. Bullard

Kansas Section—April 10-12, 1957

Water Problems and Legislation in Kansas.....	Robert L. Smith
Water and Sewage Facilities for Kansas Turnpike.....	Clifford Sharp
Public Relations and Your Job.....	Harry L. Morris
Panel Discussion—Effects of the Severe Drought on Kansas Cities and How to Live With It.....	R. W. Cunningham, Carl Wortman, Bernard Budd & Don Overman
Address of Welcome.....	Mayor A. E. Howse
Response.....	B. H. Van Blaricum
The Water Works Industry in the Water Resources Picture.....	Fred Merryfield
Construction Grants for Municipal Sewage Works.....	Dwight F. Metzler
Two Years in Jordan.....	Roger Lee
Consulting Engineer's Responsibility During and After Construction of Plant.....	Murray A. Wilson
Manufacturing and Laying of Asbestos-Cement Pipe.....	E. W. Spinzig Jr.
Repair of Water Mains.....	Luther L. Smith
The Importance of Water Works Records.....	O. R. Green
Panel Discussion—The Question Box.....	Led by Harley Lucas G. Dorr Pelton, Orville Kuran, Karl J. Svaty & A. P. Flynn
Bargain Basement Water Rates.....	J. W. Heiney
Use of Activated Silica as a Coagulant Aid.....	V. W. Langworthy

Kentucky-Tennessee Section—September 23-25, 1957

Address of Welcome.....	Mayor Andrew Broadus
Response.....	R. L. Lawrence Jr.
Penny-Wise Water.....	Lewis S. Finch
Water and Sewage Treatment in Emergencies.....	H. P. Cramer
Utility Accounting Practices.....	W. G. Thomas & Sterling S. Gregory
Butterfly Valves.....	Henry C. Schwenk
Iron and Manganese Removal.....	E. J. Connelley Jr.
Effects of Storage Impoundments on Water Quality.....	M. A. Churchill
New Developments in Taste and Odor Control in Kentucky and Tennessee.....	E. A. Sigworth
Coagulation Experiences.....	Percy Johnson
Panel Discussion—Plant and Distribution Problems.....	Led by Hunter Owen
Distribution Problems.....	Joe W. Lovell
Plant Problems.....	John Quinn
Plant Expansion—Louisville Water Company.....	William H. Richardson

Michigan Section—September 25–27, 1957

Address of Welcome.....	Acting Mayor Louis C. Miriani
Response.....	W. E. Smith
News From the Field.....	John E. Vogt
History of Water Treatment in Detroit.....	William M. Wallace
Detroit's New Northeast Water Filtration Plant	
General Description.....	A. C. Michael
Chemical Treatment, Mixing, Flocculation and Sedimentation.....	G. I. Stormont
Rapid Sand Filtration Rates, Equipment, and Instrumentation.....	Douglas Feben
Symposium on Maintenance	
Fire Hydrants and Policy on Fire Meters.....	Tony Eikey
Pavement Breaking and Repairs.....	Joseph M. Rogeven
Emergency Repairs in System.....	Albert Sabo
Elevated Tanks.....	E. D. Barrett
Handling and Feeding of Chemicals	
Alum.....	George Hazey
Fluoride.....	W. L. Harris
Lime.....	John F. Dye
Millipore Filter in Bacteriological Analysis.....	Irving L. Dahljelm
Filtration Rates.....	Herbert E. Hudson Jr.
Bacterial Loadings on Water Treatment Plant.....	Graham Walton
The Wayne County Water Supply	
The Development of the System.....	George Bingham
Detroit River Survey.....	Frank P. Coughlan Jr.
Functional Design of the Wayne County Filtration and Pumping Plant.....	Alfred W. Sawyer
Winchester Village Water Supply.....	Robert H. Zumstein
Design of Sheetpile Retaining Walls and Trench Bracing.....	William S. Housel
Population Forecasts.....	Paul M. Reid
Cost of Projects and Interest Rates.....	J. Dean Stanley

Missouri Section—September 29–October 1, 1957

Address of Welcome.....	Mayor Raymond R. Tucker
Penny-Wise Water.....	Lewis S. Finch
Panel Discussion—Pollution (Control and Trends) on Mississippi and Missouri Rivers....	Led by Allen H. Wymore
Pollution Abatement Outside Missouri.....	Vance C. Lischer
Pollution Abatement in Missouri.....	Jack K. Smith
Future Stream Flows.....	Thomas F. Maher
Shell Oil Industrial Waste Treatment.....	L. C. Burroughs
Recent Developments in Water and Sewage Pipe Joints.....	John Steencken & Bart Bretz
How and When to Select a Consulting Engineer.....	Houston M. Smith
Water Waste and Leak Detection on Distribution System	
St. Louis Techniques.....	Carl F. Buettner
Value of Pitometer Survey.....	W. D. Hudson
Facility Expansion of St. Louis Water Division.....	C. B. Briscoe
Water Meters and Shop Practice	
Testing and Calibration.....	David J. Ford
Maintenance.....	John L. Ford
Epoxy Paints for Meters.....	F. Weber
Panel Discussion—Adequate Water During Drought Periods.....	Led by Leonard Dworsky
Action of Missouri State Highway Commission Regarding Reimbursement of Utilities as Per Revised Highway Act.....	Rex Whitton
Long-Range Planning of Water and Sewerage Facilities.....	Eugene Meyer
Storage Tank Inspection and Maintenance.....	K. O. Kessler
Measuring of Remote Water Levels.....	Walter Messner

Montana Section—April 4-6, 1957

Address of Welcome.....	Mayor Russel Conklin
Response.....	Verne Reed & Ben Chestnut
Symposium on Waste Disposal.....	Led by C. W. Brink, John Hazen, C. A. Cromwell, R. L. Kimmons & N. H. Sandberg
Legal Responsibilities of Water and Sewage Utilities.....	James Battin
The Use of the McIlroy Analyzer on Water Distribution Systems.....	Charles Barker
Current Happenings in Legislature.....	Alfred Klingler
The Water Works, Pacesetter of Progress.....	Paul Weir
Industrial Development With Regard to Water.....	Perry Roys

Nebraska Section—April 24-26, 1957

Address of Welcome.....	Mayor Bennett Martin
Response.....	Carl L. Fisher
Season and Special Utility Rates.....	Del A. Blatchford
Atomic Energy Development.....	R. N. Slinger
University of Nebraska Conference Reports.....	Robert W. Mills
1903 Utility Construction Costs.....	Ernest Hansen
Cement-Lined Pipe—Its Benefits and Use.....	Eart G. Bretz
Review of Laws Affecting Water Resources.....	Robert Perry
Sacred Cows.....	Maurice E. Cole
The Use of Demand Metering for Commercial Electric Accounts.....	Albert Learned
Review of Federal Sewage Law No. 660.....	Glen J. Hopkins
Status of 1957 Legislation.....	Al G. Wurst

New Jersey Section—October 24-26, 1957

New Jersey Water Supply.....	Charles H. Capen
Full Development of Newark's Pequannock River Water Supply.....	Arthur J. Simpson G. Gale Dixon & Herbert L. Kauffmann
Preliminary Report of the Geology and Ground Water Resources of Cape May County, N.J.	Harry E. Gill
Successful Control of an Excessive Lawn-sprinkling Load.....	Robert M. Grieve
The Use of Audio Tones in Water Systems.....	L. C. Menkes
Committee Report—The Effect of Temperature on Backwash Rates of Anthrafil Media..	Peter E. Pallo
Committee Report—The Status of the Membrane Filter Technique as of 1957.....	Ernest R. Segesser
Committee Report—The Dorr-Clone and Its Application to Lime Treatment.....	Peter E. Pallo & David R. Horsefield
Safeguarding Water Supplies in the Atomic Age.....	William H. Aaroe & Byron E. Keene
Comparison of Taste and Odor Problems and Controls in New Jersey and the United States.....	E. A. Sigworth
Taste and Odor Problems and Controls.....	Attmore E. Griffin
The Prudent Man.....	John H. Murdoch Jr. & Henry A. Riddle

New York Section—April 10-12, 1957

Discussion of Matching Funds and Surplus Property Available to Water Departments for Civil Defense.....	Raymond Barbuti
Panel Discussion—Storage on the Distribution System.....	Led by George E. Symons
The Economics of Storage Versus Main Strengthening in a Distribution System.....	Donald E. Stearns
Various Types of Storage Facilities.....	Robert G. Holzmacher
Comparison of Elevated Storage Versus Ground Storage.....	Samuel C. McLendon

- Aerial Surveys as Applied to Watershed and City Areas.....Maurice J. Perrier
 The Effect of a Synthetic Detergent on the Chlorination of Water.....Charles D. Gates
 Can the Water Works Industry Attract and Hold Competent Personnel?.....William T. Ingram
 The Water Works, Pacesetter of Progress.....Paul Weir
 Round Table Conference.....Led by Angus D. Henderson

New York Section—September 11-13, 1957

- Basic Hydraulics.....George E. Symons
 Hydraulics in the Distribution System.....Robert J. Sweitzer
 The Use of Fire Hydrant Flow Tests.....George F. Hoag
 The Successful Control of an Excessive Lawn-sprinkling Load.....Robert M. Grieve
 Iron and Manganese in Water Supply.....Thomas M. Riddick
 Liquid Alum Application.....George H. Straub
 Round Table Discussion.....Led by Donald E. Stearns

North Carolina Section—November 11-13, 1957

- Address of Welcome.....Mayor W. G. Enloe
 Raleigh's Utilities.....E. M. Johnson
 Pilot Plant Research at Cone Mills.....R. H. Souther & Tom Alspaugh
 Panel Discussion—Impact of Federal Aid Highways on Utilities Systems
 Municipalities.....Tom Z. Osborne & Leonard P. Bloxam
 State Highway Commission.....W. H. Webb Jr.
 Summary and Discussion.....John T. Morrissey
 The Seven City Water Project.....George A. Covington
 Color Removal in Municipal Sewage Treatment Plants.....Nelson L. Nemerow
 Pneumatic Controls for Water and Sewer Plant Instrumentation.....David Tobin
 Sizing of Water Meters.....Charles Floyd & Paul McCullough

North Central Section—September 25-27, 1957

- Water and Sewage Pump Maintenance.....David Gallagher
 Use of Plastic Pipe in Water Distribution.....Howard M. McDaniel
 Federal Aid for Sewerage Construction.....Paul Bolton
 Design Features of Grand Forks Water Plant Addition.....Allan H. Wymore
 Discussion.....Robert M. Jensen
 Design and Operation of Small Water Plants.....Johnny Klingenberg
 Discussion.....Ralph Dwelle & Carl Torkelson
 Steel Water Tank Maintenance and Repair.....Ted E. Welk
 Central Missouri River Water Quality Investigation.....Joe K. Neel
 Discussion.....William Yegen, Robert Shaw, Don Wessel & James L. Jensen
 Sewage Treatment Facilities for Williston [N.D.].....Herbert Arnold
 Reports from State Health Departments.....Charles E. Carl, Frank L. Woodward & W. L. Van Heuvelen
 Panel Discussion—Water Plant Operation.....Led by John A. Oakey
 Panel Discussion—Sewage Plant Operation.....Led by George J. Schroepfer
 Penny-Wise Water.....Lewis S. Finch
 Recarbonation in Water Treatment.....Dean E. Colvin
 Discussion.....Glenn Berg & Clayton M. Bach
 Public Works Development in New Subdivisions.....Edward J. Booth

Ohio Section—September 18–20, 1957

Address of Welcome.....	Mayor Charles P. Taft
Water Quality, Monitoring Project.....	D. A. Robertson
Finance Operation, Billing, and Collection.....	Charles T. Rupert
One More Pipe Size.....	A. M. Friend
New Chemicals Used in Water Treatment.....	Leo Louis
Important Features of the New Water Supply at Columbus.....	Paul Laux
General Discussion of Plant Operation and Problems—A Discussion....	Led by Robert Holt
New Construction at Mentor, Ohio, and Expanding Water Service in Western Lake County	W. Robert Bowman
Present Day Factors Tending to Limit the Financing of New Construction..	Alfred LeFeber
Membrane Filter.....	Dan Enright
Control of Chlorination.....	R. J. Baker & A. E. Griffin
Water Main Cleaning and Coating.....	K. P. Stearns
Current Research Activities of the Association of American Soap and Glycerine Producers	F. J. Coughlin
A 1957 Look at Coagulation and Coagulants.....	R. W. Kirkconnell
Extension of 48-in. Concrete Water Main in Abandoned City Subway.....	Harry Rimmer
New Tyton Joint for Cast-Iron Pipe.....	P. K. Farrington
Satisfying Peak Demands During the Summer.....	Frank J. Schwemler
Reclamation of Lime.....	L. C. Huffman

Pacific Northwest Section—May 2–4, 1957

Address of Welcome.....	Gerrit VanderEnde
Water Resources of the Future.....	Fred Merryfield
Panel Discussion—Water Requirements for Industry and Expanding Population	
Pulp and Paper Industry.....	Merrill Robison
Canning Industry.....	Virgil O. Scott
Cities and Water Districts.....	C. V. Signor, James R. Baun & J. E. Morrison
Panel Discussion—Development of Surface Supply	
Capilano Dam.....	K. E. Patrick
Tolt River Supply.....	J. Ray Heath
Union River Dam.....	John W. Cunningham
Bull Run Dam No. 2.....	H. Loren Thompson
Microstraining.....	G. R. Evans
Development of Underground Supply	
Ranney Wells.....	John R. Wallace Jr. & Robert A. Yale
Deep Wells.....	H. S. Baarslag Jr. & Richard W. McCann
Tacoma's Supply and Distribution System.....	W. A. Kunigk
Catholic Protection.....	N. Kerry Patterson & Robert L. Lee
Demonstration of Pipe Locators, Pipe Tapping, Meter Testing, and Radio Communication	A. J. Benedetti & S. B. Smith
Electrical Supervisory Control....	John L. Green, Marvin H. Schroeder & Sigurd Turnquist
Tacoma Reservoirs.....	George E. Hopkins

Pennsylvania Section—June 12–14, 1957

Panel Discussion—Water Works Practice	
Management.....	Wendell R. LaDue
Distribution.....	Samuel S. Baxter
Legal Aspects.....	William H. Markus

Panel Discussion—Rehabilitation—Pittsburgh Water Works

General.....	John A. Murphy
Cleaning Basins and Mains.....	Morris Wolf
Clarification and Purification.....	Robert Morris
Pumping Station Electrification.....	E. F. Twomey
Theories of Adsorption With Activated Carbon.....	John W. Hassler
Membrane Filter vs MPN Method for Coliform Determination.....	R. B. Adams
Relation of Radioactive Substances to Water Supply.....	Simon Kinsman
Dramatization—A Typical Rate Case.....	Led by Jay H. Eisaman

Rocky Mountain Section—September 23-25, 1957

Address of Welcome.....	Stanley J. Leland
Coliform Removal in Water Treatment Processes.....	Graham Walter
Ditonite Filters.....	R. C. Platt
Problems Arising From Radioactive Fallout From Nuclear Detonations Regarding Water-shed or Reservoir Water Supplies.....	P. W. Jacoe
Reservoir Evaporation Control.....	Lloyd Timblin
Customer Complaints.....	Jack Maguire
Service Policy to Fringe Areas.....	Thomas Eaton
Water Main Extension Policies to Fringe Areas vs Local Areas.....	Sid Nichols
Automation and Application of Electronics in the Utility Field.....	Henry Prechtel
Personnel Developments, Salary Scales, Recruiting, and Training.....	Robert S. Millar
Factors in the Design of Chlorination Stations as Regards Size, Safety, Operation, Control, and Maintenance.....	John Strait
Safety Manual of AWWA.....	Tom Eaton

Southeastern Section—March 17-19, 1957

Address of Welcome.....	Mayor W. McG. Morrison
National Association Affairs.....	Paul Weir
Southeastern Section Affairs.....	Carl C. Lanford
Sampling and Testing Drinking Water.....	Elizabeth McEntire & A. T. Storey
The Bushy Park Water Development.....	Arthur Field & Francis B. McDowell
Customer Relations.....	Allan Mustard
Panel Discussion—Selecting Proper Size Meters.....	Led by Wm. R. Wise, Harry J. Siebert, Charles Floyd Jr. & Alan McC. Johnstone
Control and Instrumentation Systems.....	Robert C. Kauffman
Symposium—Operator Recruiting, Training, and Certification.....	W. A. Hardenbergh & Raymond J. Faust
Development of Rural Public Water Supplies.....	J. M. Roberts & Riley Milam

Southwest Section—October 13-16, 1957

Address of Welcome.....	Mayor Allen Street
Response.....	Karl Hoefle
The Oklahoma City Water Supply—Present Water Works System.....	Frank S. Taylor

Research on Taste and Odor.....	J. K. G. Silvey
Central and Southeast Oklahoma Water Supply and Canal Project.....	Guy Treat
Evaporation Reduction Studies on Lake Hefner, Oklahoma City, Okla.....	M. G. Barclay, L. O. Timblin Jr., Bernard E. Berger, S. K. Jackson, Stuart D. Whitford & J. K. G. Silvey
Cloud Seeding and Long-Range Weather Forecasting in Water Planning.....	Newt Stone
Discussion.....	M. B. Cunningham, Tom Amiss & Karl Hoeffle
A New Standard of Precision in Microfiltration and Analysis—Motion Picture.....	Millipore Filter Corp.
Aerial Mapping.....	Daniel Kennedy
Panel Discussion—Pollution Control of Water Supply Reservoirs.....	Lloyd F. Pummill, Glen T. Kellogg, John E. Trygg & Henry L. Dabney
Frontiers of Science Foundation of Oklahoma, Inc.	James G. Harlow
Panel Discussion—Distribution System Problems.....	Led by Henry Graeser, Ralph Hardy & R. B. Rau
Value of Inventory and Accounting Controls in Water Works Operation....	Jack Wilson
Safety First?.....	Sam Wantland
Discussion.....	Harvey G. Freehauf

Virginia Section—November 6-8, 1957

Panel Discussion—Liquid Alum.....	S. M. Hodges, H. E. Lordley & R. W. Ockershausen
A New Method of Fine Straining for Water Supplies.....	G. E. Evans
Public Information Activities.....	Fred Merryfield
Discussion of Short School for Operators.....	H. E. Lordley
Discussion of Operators Certification Program.....	C. G. Haney
Blacksburg-Christianburg—V.P.I. Water Project.....	W. Martin Johnson
Panel Discussion—Accident Prevention.....	X. D. Murden, F. H. Miller & Donald Cook
Bacterial Removal from Water Supplies by Use of Ion Exchange Resins.....	W. A. Parsons & J. J. Blair III
Panel Discussion—New and Old Water Plant Construction in Virginia.....	Brent Ramsburg, F. L. Showalter & R. D. Wright
Disposal of Radioactive Wastes.....	J. M. Morgan Jr.
The Relationship Between Public Water Supplies and Planning and Economic Development in Virginia.....	W. H. Caldwell
The People Business or Just Plain Folks.....	Walter A. Flick

West Virginia Section—October 23-24, 1957

Williamson Settling Basin.....	W. S. Staub
Flood Damage—Tug and Big Sandy Rivers.....	Glen Fortney
Coagulation and New Coagulant Aids.....	R. W. Kirkconnell
Use of Chlorine and High Residuals.....	John Millar
National Representative—AWWA.....	Wendell L. LaDue
Mud Tub—Demonstration of Corrosion.....	A. E. Erickson
Membrane Filter.....	T. J. Blair III
Water Treatment for Air Conditioning.....	R. G. Dalbke
A Dollar and Sense Approach to Corrosion Control.....	W. J. Reese
Demineralization of Water.....	Howard E. Frazer

Wisconsin Section—September 4-6, 1957

Address of Welcome.....	Mayor Frank P. Zeidler
New Techniques in the Location of New Sources of Water.....	Robert Spanski
Recharging Water Bearing Formations.....	O. J. Muegge
Turbine Pumps as Boosters.....	Donald Johnson
Pumping Systems Without Elevated Storage.....	Douglas G. Maxwell
Underwriters' Interest in Fire Protection.....	John Wilkinson
Sizing Water Service Piping.....	Arthur Rynders
Mobile Communications in Water Utilities.....	Nathan Boruszak
Water Requirements for Air Conditioning.....	Guy R. Scott

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Section Meetings—1953-1957

Section	1953	1954	1955	1956	1957	Meeting Place—1957
Alabama-Mississippi	Oct. 4-7	Oct. 24-27	Oct. 30-Nov. 2	Oct. 21-24	Oct. 20-23	Biloxi, Miss.
Arizona	Apr. 16-18	Apr. 22-24	Apr. 14-16	Apr. 5-7	Apr. 4-6	Mesa, Ariz.
California	—	Apr. 9*	Apr. 13*	Apr. 13*	Apr. 26*	Santa Monica, Calif.
Canadian	Oct. 27-30	Oct. 26-29	Oct. 25-28	Oct. 23-26	Oct. 29-Nov. 1	San Jose, Calif.
	Apr. 6-8	Apr. 12-14	Apr. 18-20	Apr. 23-25	Jun. 17-19	Winnipeg, Man.
	Sep. 21-22†	Oct. 4-5†	Oct. 17-18†	Oct. 15-16†	Oct. 17-18†	Halifax, N.S.
	Oct. 28-30	Oct. 27-29	Oct. 26-28	Oct. 24-26	Oct. 30-Nov. 1	Washington, D.C.
Chesapeake	Dec. 3-5	—	Dec. 1-3	Nov. 29-Dec. 1	§	—
Cuban	Oct. 11-13	Nov. 7-10	Nov. 6-9	Nov. 11-14	Nov. 10-13	Jacksonville, Fla.
Florida	Mar. 18-20	Mar. 17-19	—	Mar. 21-23	Mar. 20-22	Chicago, Ill.
Illinois	Feb. 11-13	Feb. 10-12	Feb. 9-11	Feb. 8-10	Feb. 6-8	Indianapolis, Ind.
Indiana	Oct. 14-16	Oct. 13-15	Oct. 19-21	Oct. 24-26	Oct. 16-18	Des Moines, Iowa
Iowa	Apr. 22-24	Apr. 7-9	Apr. 13-15	Apr. 4-6	Apr. 10-12	Wichita, Kan.
Kansas	Sep. 21-23	Sep. 20-22	Sep. 12-14	Sep. 17-19	Sep. 23-25	Louisville, Ky.
Kentucky-Tennessee	Sep. 3-4	Sep. 15-17	Sep. 14-16	Sep. 12-14	Sep. 25-27	Detroit, Mich.
Michigan	Sep. 27-29	Sep. 26-28	Sep. 25-27	Sep. 30-Oct. 2	Sep. 29-Oct. 1	St. Louis, Mo.
Missouri	Apr. 24-25	Apr. 23-24	Apr. 29-30	Apr. 6-7	Apr. 4-6	Great Falls, Mont.
Montana	Apr. 16-17	Apr. 22-23	Apr. 13-15	Apr. 11-13	Apr. 24-26	Lincoln, Neb.
Nebraska	—	—	—	—	—	—
New England	Oct. 22-24	Nov. 4-6	Oct. 20-22	Oct. 18-20	Oct. 24-26	Atlantic City, N.J.
New Jersey	Apr. 16-17	Apr. 22-23	Apr. 20-22	Apr. 18-20	Apr. 10-12	Elmira, N.Y.
New York	Sep. 9-11	Sep. 9-10	Sep. 7-9	Sep. 12-14	Sep. 11-13	Upper Saranac Lake, N.Y.
North Carolina	Nov. 9-11	Nov. 8-10	Nov. 14-16	Nov. 12-14	Nov. 11-13	Raleigh, N.C.
North Central†	Sep. 1-5	Oct. 6-8	Oct. 5-7	Sep. 12-14	Sep. 25-27	Fargo, N.D.
Ohio	Sep. 10-11	Sep. 22-24	Sep. 21-23	Sep. 19-21	Sep. 18-20	Cincinnati, Ohio
Pacific Northwest	Apr. 16-18	—	May 19-21	Apr. 26-28	May 2-4	Tacoma, Wash.
Pennsylvania	Jun. 17-19	Jun. 23-25	May 4-5	Apr. 3-5	Jun. 12-14	Bedford, Pa.
Rocky Mountain	Sep. 21-23	Nov. 9-10	Sep. 19-21	Nov. 26-28	Sep. 23-25	Santa Fe, N.M.
Southeastern	Mar. 23-25	Mar. 29-31	Mar. 20-23	Mar. 18-21	Mar. 17-19	Charleston, S.C.
Southwest	Oct. 18-21	Oct. 17-20	Oct. 16-19	Oct. 14-17	Oct. 13-16	Oklahoma City, Okla.
Virginia	Nov. 4-6	Nov. 3-5	Nov. 3-5	Nov. 7-9	Nov. 6-8	Roanoke, Va.
West Virginia	Sep. 3-4	Nov. 8-9	Oct. 20-21	Oct. 31-Nov. 2	Oct. 23-24	Wheeling, W.Va.
Wisconsin	Sep. 22-24	Sep. 28-30	Sep. 21-23	Sep. 26-28	Sep. 4-6	Milwaukee, Wis.

§ Meeting Canceled.

† Formerly Minnesota State.

† Maritime Branch.

* Regional meetings.

**Section Membership at Time of, and Total Attendance at,
Section Meetings—1953-1957**

Section	1953		1954		1955		1956		1957	
	Mem- bership	Attend- ance	Mem- bership	Attend- ance	Mem- bership	Attend- ance	Mem- bership	Attend- ance	Mem- bership	Attend- ance
Alabama-Mississippi...	177	182	189	311	206	257	219	318	224	307
Arizona.....	72	41	76	199	68	157	77	156	84	234
California§.....	1,084	1,126	1,193	1,709	1,291	1,037	1,378	1,253	1,451	1,225
Canadian§.....	581	617	608	848	629	714	663	816	708	500
Chesapeake.....	247	224	248	210	258	211	267	191	288	228
Cuban.....	72	32	69		54	*	52	43	62	
Florida.....	327	287	328	305	342	306	355	331	361	399
Illinois.....	482	407	504	474	527	†	557	468	589	474
Indiana.....	330	386	332	399	392	475	409	421	478	499
Iowa.....	121	178	133	191	137	286	149	220	181	282
Kansas.....	206	170	220	191	229	208	237	236	239	217
Kentucky-Tennessee...	186	203	189	294	201	259	221	317	252	317
Michigan.....	349	164	386	263	411	236	435	278	471	341
Missouri.....	189	242	198	260	206	230	228	275	238	306
Montana.....	58	107	55	117	57	76	54	84	61	132
Nebraska.....	82	224	95	200	94	164	103	183	109	156
New England.....	218	†	218	†	225	†	233	†	248	†
New Jersey.....	414	318	436	340	435	313	463	351	505	336
New York§.....	741	355	805	420	826	315	851	429	882	458
North Carolina.....	188	294	191	255	202	281	232	326	224	305
North Central#.....	229	166	241	179	238	162	260	157	278	177
Ohio.....	403	252	445	406	468	251	482	253	508	281
Pacific Northwest.....	345	346	441	†	440	293	438	304	507	358
Pennsylvania.....	455	204	465	234	493	255	516	295	558	235
Rocky Mountain.....	156	125	170	100	171	94	186	164	237	152
Southeastern.....	203	205	246	313	267	325	278	319	300	335
Southwest.....	938	803	945	681	1,047	850	1,086	889	1,133	784
Virginia.....	179	226	188	230	192	237	207	233	213	241
West Virginia.....	102	120	103	212	100	152	104	126	105	195
Wisconsin.....	181	288	182	316	190	291	199	296	206	340

* No record of attendance.

† No regular meeting scheduled. Membership given as of dates of conferences.

‡ Regular meeting canceled. Business meeting held at annual conference.

§ Only one of section's meetings recorded here.

|| Meeting canceled.

Formerly Minnesota Section.

Subject Index

A

Accidents; *see* Safety
 Accounting; system of, for small plants, 21
 Acidizing; well maintenance by, 818
 Activated carbon; effectiveness of odor control with, 1517
 Activated silica; use of, in treatment of textile-finishing water, 459 (erratum, 824)
 Administration; water works; report of committee on, 331
 Agriculture; *see* Irrigation
 Air conditioning; Chicago, Ill., problems due to, 697
 demand charges for, at Kansas City, Mo., 705
 expansion and regulation of, 217
 Alcohol; reservoir evaporation control with, 398, 841
 Alexandria, Va.; automatic control of multiple-treatment units at, 776
 Algae; *see* Aquatic organisms and growths
 Alum; liquid; experience with, in various cities, 1315
 use of, at Milwaukee, Wis., 52 (erratum, 276), 1321
 American Sanitary Engineering Intersociety Board; organization of, 191
 American Standards Association; availability of revised edition of cast-iron pipe manual of, 1278
 American Water Works Association; annual conference—Atlantic City, N.J., 1595
 audit of funds; report of, 361
 awards; individual, 1597
 safety; plan for, 339
 section membership; standings for, 367
 California Section; resolution of, on state water plan, 143
 certification program of, 1521
 committee reports and activities; effects of synthetic detergents, 1355
 fluoridation materials and methods, 417
 national water policy, 825
 revenue-producing water, 1587
 underground waste disposal and control, 1334
 water works administration, 331
 water works practice, 341 (erratum, 391)

AWWA (*contd.*); membership statistics for, 368
 policy of, on membrane filter procedure, 1530
 public relations program of, 357
 publications report, 349
 section meeting programs and attendance, 1605
 standards; cast-iron pipe manual (ASA A21.1, AWWA C101); availability of revised edition of, 1278
 change in nomenclature of, 992
 meter testing (C705); availability of, 936
 steel pipe coatings (C203); new edition of, 941
 steel pipe joints (C206); revision of, 312
 Analog computers; *see* Analyzers
 Analyzers; digital computer; applications of, 1046
 pipeline network; digital computers used as, 517, 1047
 McIlroy; operation of, 15
 photo of, *January cover*
 Aquatic organisms and growths; algae; control of, at Philadelphia, Pa., 215
 in Canada, 1525
 survey of problems and measures for control of, 1511
 effect of water temperature on, 406, 408
 effectiveness of microstrainer removal of, 546
 rushes; problem of, in Cincinnati, Ohio, reservoirs, 318
 Aquifers; *see also* Ground water; Recharge western Ohio; characteristics of, 464
 Artificial recharge; *see* Recharge
 ASA; *see* American Standards Association
 Ascorbic acid; use of, in fluoride determination, 1234
 Atlanta, Ga.; effects of pipe and tank linings on water quality at, 1
 Atlantic City, N.J.; aerial photo of, *April cover*
 1957 AWWA conference at, 1595
 repairs of leak at, from inside pipeline, 1195
 Atomic energy; *see* Radio-
 Audit of AWWA funds; report of, 361
 Authorities; *see also* Districts; Suburban areas
 San Diego County; organization of, 525

Automatic equipment; *see* Equipment (control)

B

- Bacteria; *see also* Membrane filters
coliform; comparison of MPN and membrane filter tests for, 1452
MPN confidence limits for, 1060
radiocarbon culture media for, 1069
simplified record sheets for test data on, 457
effect of rise in water temperature on, 406
Bactericides; *see* Chlorination; Chlorine
Baltimore, Md.; fluoridation experience at, 1239
forecasting water demand at, 225
network analyzer at, 15
Bel Air, Md.; fluoridation with fluorspar at, 37
Bicarbonate; effect of, on zinc corrosion inhibition by sodium silicate, 1432
Billerica, Mass.; liquid alum for coagulation at, 1331
Billing; monthly; evaluation of, 1103
1955 data on, 617 (erratum, 1580)
analysis of, 1545
Bonds; *see* Financing
Book value; 1955 data on, 644 (erratum, 1580)
analysis of, 1559
Booster stations; *see* Pumping stations
Brookneal, Va.; use of activated silica at, 459 (erratum, 824)
Burnsville, W.Va.; rebuilding of system at, 148

C

- Cadmium; physiological effects of, 1310
Calcining; sludge; process for, at Lansing, Mich., 327
study of, 1343
Calcium carbonate; inhibition of cast-iron pipe corrosion by, 1298, 1303
Calcium fluoride (fluorspar); practicability of fluoridation with, 34
California; *see also* Coalinga; East Bay Municipal Utility District; Los Angeles; Palo Alto; San Diego County; San Francisco
growth of urban demand in, 1053 (erratum, 1451)
map of proposed aqueduct system for, February cover
operation of Water Rights Board of, 105

- California (*contd.*); sea water intrusion in, 71
Southern; Water Coordinating Conference; statement of, on basic principles of water development, 144
water plan; administration of, 89
role of various groups in, 993
California Section, AWWA; resolution of, on state water plan, 143
Canada; *see also* under provinces
fluoridation statistics for, 41, 1478
treatment practices in, 1522
Carbon; activated; effectiveness of odor control with, 1517
Carbon dioxide; well maintenance with, 817
Carbonate; *see* Bicarbonate; Calcium carbonate
Carbonation; *see* Calcining
Cast-iron pipe; *see* Pipe; Pipelines
Cement linings; methods of application of, 1036, 1039
solution effects of water on, 1441
Certification; operator; Illinois program for, 888, 890
sanitary engineer; intersociety board for, 191
state programs for, 1292
water works material; AWWA program for, 1521
Charges; *see also* Air conditioning; Fire protection charges; Rates
minimum; 1955 data on, 617 (erratum, 1580)
analysis of, 1546
Charleston, W.Va.; preparation for rate increase at, 151
taste and odor problems at, 309
Charlotte, N.C.; fluoridation experience at, 1239
Chicago, Ill.; air-conditioning demand problems at, 697
fluoridation experience at, 1239
liquid alum for coagulation at, 1322
safety record of, 940
Chloride; direct spectrophotometric determination of, 1485
Chlorination; effect of water temperature on, 407
remote control of, 795
taste and odor control by, 1518
Chlorine; diethyl-*p*-phenylene diamine for determination of, 873
stationary storage facilities for, at Tampa, Fla., 223
Chromium; physiological effects of, 1311

- Cincinnati, Ohio; aquatic growths in reservoirs at, 318
 suburban; water supply for, 322
 Cleveland, Ohio; main cleaning and lining at, 1029
 Climate; relation of, to fluid intake and optimum fluoride content, 1233
 Coagulation; Canadian practices in, 1522
 effect of water temperature on, 409
 experience with liquid alum for, at Milwaukee, Wis., 52 (erratum, 276), 1321
 in various cities, 1315
 hydraulics of and aids in, 242
 jar tests for, 1414, 1425
 use of aids in, 1524
 Coal-tar coatings and linings; cast-iron pipe; electrolytic application of, 1032
 steel pipe; new edition of AWWA standard for, 941
 Coalinga, Calif.; importation of water by, 113
 Coatings; *see* Cement, Coal-tar; Linings
 Coliform bacteria; *see* Bacteria
 Colorado; *see* Denver
 Colorimetry; fluoride determination by, 417
 Committee reports; *see* American Water Works Association
 Complaints; water quality; handling of, 785
 Computers; *see* Analyzers
 Concrete pipe; solution effects of water on, 1441
 use of, for transmission lines, 1360
 Conservation; *see* Air conditioning; Evaporation
 Construction; equipment for, in small utilities, 910
 1955 data on sources of funds for, 644
 analysis of, 1557
 problems in financing of, 1593
 public relations aspects of, 791
 transmission line; considerations in, 1359
 Consultants; *see* Engineers
 Consumption; *see also* Demand
 fluid; effect of climate on, 1233
 water; areal statistics on, by types of land use, 1054 (erratum, 1451)
 effects of lawn sprinkling restrictions on, 267
 1955 estimate of, 369
 1955 survey data on, 591
 analysis of, 1539
 trends in, 168, 225
 Control equipment; *see* Equipment
 Corrosion; *see also* Linings
 cast-iron pipe; effect of natural coatings on, 1298, 1303
 study of, in Great Lakes water, 1294
 Corrosion (*contd.*); evaluation of polyphosphates for control of, 1581
 evaluation of "water conditioner" units for control of, 1179 (erratum, 1477)
 stray-current; distribution systems affected by, 881
 use of sodium hexametaphosphate for control of, 805, 1200
 zinc; inhibition of, by sodium silicate, 1432
 Costs; electronically operated equipment, 1048, 1050
 fluoride chemicals, 43
 liquid alum, 52 (erratum, 276)
 long-distance transmission lines, 1361
 meter reading and maintenance, 1462
 sludge calcining, 329
 suburban water systems, 1139
 types of records of, 21
 upland storage, 279
 water works; 1955 data on, 643
 analysis of, 1553
 graph of, *December cover*
 well dynamiting, 823
 Courts; *see* Legislation; Liability
 Culture media; *see* Bacteria; Membrane filters
 Customers; *see* Consumption; Demand; Public relations; Services

D

- Dallas, Tex.; adequacy of water utility earnings at, 1115
 Dams; *see also* Flood control
 New Croton; spillway leak repairs at, 198
 Danville, Va.; adequacy of water utility earnings at, 1130
 Delaware; water resources of, 731
 Demand; *see also* Consumption
 air-conditioning; Chicago, Ill., problems due to, 697
 Kansas City, Mo., study of, 705
 load factor in, 219
 growth of, at Dallas, Tex., 1123
 in California urban areas, 1053 (erratum 1451)
 in New Mexico, 475
 in San Diego County, Calif., 525, 531
 irrigation; growth of, in Illinois, 537
 peak; storage requirements for, 263
 trends in, 228
 rate differentials for control of, at Kansas City, Mo., 705
 residential-fixturing; determination of, 1191
 Demineralization; salt water; description of processes for, 1007

- Denver, Colo.; photo of Roberts Tunnel at, *March cover*
 water resources development for, 251
- Depreciation; 1955 data on, 644
 analysis of, 1557
- Wisconsin Public Service Commission
 views on, 162
- Design; automatic and remote control equip-
 ment, 1375, 1378
 butterfly valves, 772
 meter settings, 1459
 treatment plant; aspects of, 413
 underground distribution reservoirs, 1499
 underground pumping stations, 491
 upland storage, 279
 transmission line; considerations in, 1359
- Detergents; *see* Synthetic detergents
- Detroit, Mich.; handling of water quality
 complaints at, 785
 lawn-sprinkling restrictions at, 267
- Development; suburban water system; costs
 of, 1139
 water resources; California; plan for, 89
 role of various groups in planning of,
 993
 Denver, Colo.; description of, 251
 New Jersey problems of, 969
- Diatomite filters; survey of, 174 (erratum,
 438)
- Digital computers; *see* Analyzers
- Disinfection; *see* Chlorination; Chlorine
- Distribution systems; *see also* Pipe; Pipe-
 lines; Pressure; Pumping stations;
 Services; Reservoirs; Storage; Tanks
 1955 data on, 565
 analysis of, 1541
 records and inspection of, at Madison,
 Wis., 499
 remote control of, at Vancouver, Wash.,
 1387
 on Long Island, N.Y., 1371
 stray-current corrosion of, 881
 study of hydraulics of, with digital com-
 puters, 517, 1047
 with McIlroy network analyzer, 15
- Districts; *see also* Authorities; Suburban
 areas
 Michigan; financing of, 859
 Winnipeg, Man.; operation of, 1389
- DPD (diethyl-*p*-phenylene diamine); chlo-
 rine determination with, 873
- Dynamite; well redevelopment with, 819
- Employees; *see also* Certification; Engi-
 neers; Safety; Training
 effect of fluoride handling on health of,
 1248
 1955 data on, 616
 analysis of, 1545
 recruiting of, 1279, 1283
 small-plant; Illinois survey of training and
 duties of, 887
- Engineer Corps; *see* Government (US)
- Engineers; overcoming shortage of, 469
 role of, in planning water resources devel-
 opment, 998
 sanitary; intersociety board for certifica-
 tion of, 191
- Engineers Joint Council; photo of display at
 Nuclear Congress of, *June cover*
- Epoxy resin; use of, in leak repair, 1197
- Equipment; *see also* Analyzers
 construction; for small utilities, 910
 control; automatic and remote; chemical
 feeders, 1378
 chlorine residuals, 795
 distribution system, 1371, 1387
 multiple-treatment units, 777
 pumping stations, 47
 types of signal for, 1375
 valves, 301
 electronically operated; water works appli-
 cations of, 1043
 fluoride handling and feeding, 1241, 1252
 laboratory; fluoride color comparators, 417
 jar tests, 1415, 1425
 liquid-alum handling and feeding, 1316
 radioassay water sampling, 754
 sludge calcining, 327
- Escherichia coli*; *see* Bacteria (coliform)
- Evaporation; monomolecular film for control
 of, in reservoirs, 397, 841
- Evis "Water Conditioner"; evaluation of
 performance of, 1179 (erratum, 1477)
- Exchangers; ion; radioactivity removal by,
 1085
- Expenses; *see* Costs; Financing; Revenue
- Explosives; well redevelopment with, 819,
 898
- Extensions; *see* Suburban areas

F

- Feather River Project; California plan for,
 89
- Federal government; *see* Government (US)
- Filters; diatomite; survey of, 174 (erratum,
 438)
 membrane; *see* Membrane filters
 precast concrete underdrains for, 450

E

- East Bay Municipal Utility District, Calif.;
 recreational use of watershed of, 1172

- Filtration; microstrainers as aid in, 541
USPHS 1955 survey of facilities for, 1567
- Financing; California water project; methods of, 121
construction; difficulties in, 1593
improvement; methods of, 859
1955 data on, 644
analysis of, 1557
relation of bond market status to, 1107
relation of revenue to, 1112, 1565
suburban water system; cost estimates for, 1139
- Findlay, Ohio; upland storage facilities at, 278
- Fire flows; test procedure for, 779
- Fire hydrants; *see* Hydrants
- Fire protection; new NBFU grading schedule on, 54
- Fire protection charges; 1955 data on, 617
analysis of, 1547
- Fixtures; residential; water demand of various types of, 1191
- Flocculation; *see* Coagulation
- Flood control; California; Corps of Engineers program for, 128
Iowa law on, 738
- Florida; fluoridation experience in, 1270
Tampa; stationary chlorine storage facilities at, 223
- Flow; *see also* Hydraulics; Pressure
fire; test procedure for, 779
rate of, for residential water fixtures, 1191
tracers for studies of, 743
- Fluoridation; characteristics and handling of chemicals for, 1241
effect on health of employees engaged in, 1248
experience with, in various cities, 1239
fluorspar for, 34
introduction of, in Greater Winnipeg, Man., Water District, 1399
1955 census of chemicals, equipment, and installations for, 41
1956 election returns on, 40
1956 status of, 1478
relation of climate and fluid intake to, 1233
statistics on chemicals used for, 44, 1482
- Fluoride; accuracy of feeding devices for, 1252
ascorbic acid as complexing agent in determination of, 1234
color comparators for determination of, 417
persistence of, in distribution system, 1260
uniform concentration of, at Newburgh, N.Y., 512
- Fluorspar; practicability of fluoridation with, 34
- Fluosilicic acid; fluoridation experience with, 1239
- Forecasting; water demand; data for, 225
- Fort Worth, Tex.; peak-demand storage at, 264
- Fringe areas; *see* Suburban areas
- G**
- Gainesville, Ga.; suburban service at, 1145
- Gas indicator; methane determination with, 1077
- Geology; *see* Aquifers; Ground water
- Georgia; *see* Atlanta; Gainesville
- Giddings, Tex.; automatic controls in pumping stations at, 47
- Government; *see also* Legislation
US; Army Corps of Engineers; flood control program of, in California, 128
Bureau of Reclamation; activities of, in California, 132
saline-water conversion research of, 1007
- Great Britain; water utility reorganization in, 1001
- Great Lakes; cast-iron pipe corrosion by waters of, 1294
- Greensboro, N.C.; study of fringe area needs at, 834
- Ground water; New Mexico; investigation of, 476
Oahu; geology of, 1404
South Carolina coastal plain; description of, 283 (errata, 456, 742)
travel of pollution in, 1338
western Ohio; study of, 464
World Health Organization report on pollution of, 392
- H**
- Hawaii; *see* Honolulu
- Health; *see also* Safety
effect of cadmium and chromium on, 1310
water plant employee; effect of fluoride handling on, 1248
- Hexadecanol; biological oxidation of, 849 (erratum, 1178)
photo of dispersion of, *July cover*
reservoir evaporation control with, 398, 841
- Hexametaphosphate; corrosion control with, 805
use of, in maintaining pipe capacity after cleaning, 1200
well maintenance with, 819

Honolulu, T.H.; photo of Waikiki Beach at, *November cover*
 water supply of, 1403
 Houston, Tex.; design details in treatment plant at, 413
 Hydrants; installation and maintenance of, at Wilmette, Ill., 913
 1955 data on, 591
 analysis of, 1540
 Hydraulics; distribution system; digital computers applied to, 517, 1047
 McIlroy network analyzers for solving problems in, 15
 well design, 439
 Hydrocarbons; petroleum; measurement of small quantities of, 55
 Hydrochloric acid; well maintenance with, 818
 Hydrofluosilicic acid; fluoridation experience with, 1239

I

Illinois; *see also* Chicago; Wilmette growth of irrigation demand in, 537
 mineral analyses of rivers in, 1213
 training and certification in, 887, 890
 well construction in, 903
 Improvements; *see* Construction; Suburban areas
 Income; *see* Revenue
 Indiana; survey of water resources problems in, 70
 Indianapolis, Ind.; fluoridation experience at, 1239
 photo of Geist Reservoir at, *September cover*
 recreational use of reservoirs at, 1160
 Industrial wastes; *see* Pollution
 Industrial water; *see also* Air Conditioning; Services
 forecasting demand for, 235
 operation of southwestern Ohio system for, 313
 self-supplied; 1955 statistics on, 377
 Infestations; *see* Aquatic organisms and growths
 Inspection; distribution system; procedure for, at Madison, Wis., 499
 steel pipe coating; AWWA standard for, 947
 valves and hydrants, 913
 Instruments; *see* Equipment
 Interest; *see* Financing
 Ion exchange; mixed-bed; radioactivity removal by, 1085
 Iowa; water use law in, 733

Iron; evaluation of polyphosphate treatment of, 1582
 sodium hexametaphosphate for stabilization of, 813
 Iron removal; application of redox potential measurements to, 1223
 Irrigation; conversion of systems for, to potable-water supplies, 531
 growth of, in Illinois, 537
 1955 water use for, 375

J

Jar tests; review of development of, 1414
 turbidity measurements as criteria for, 1425
 Joints; pipe; plastic; types of, 427 (erratum, 1312)
 steel; revision of standard for, 312

K

Kalamazoo, Mich.; well construction and maintenance at, 905
 Kansas City, Mo.; rate differentials for high-demand control at, 705
 suburban; tornado survived by elevated tank at, *October cover*, 1313
 Knoxville, Tenn.; comparison of earnings of various utilities in, 1135
 safety program at, 937

L

Laboratory apparatus; *see* Equipment
 Lansing, Mich.; maintenance of rock wells at, 817
 sludge calcining at, 327
 Lawn sprinkling; effects of restrictions on, 267
 Leaks; *see also* Unaccounted-for water
 repair of, from inside of pipeline, 1195
 Legislation and regulation; California; water resources, 92, 99, 135
 water rights, 105, 135
 eastern states; water rights and use, 721
 Illinois; operator certification, 888, 890
 Michigan; district and authority financing, 862
 Oregon; water use, 986
 state; diatomite filters, 174 (erratum, 438)
 reservoir lands, 1153
 Virginia; water rights and use, 717
 Washington; reservoir lands, 1171
 West Virginia; rates, 154
 Wisconsin; publicly owned utility taxation, 1369
 rates, 160

- Liability; court rulings on, in main break cases, 1025
 Licensing; *see* Certification
 Lime; reclamation of, affected by magnesium, 1343
 at Lansing, Mich., 327
 Linings; *see also* Coal-tar
 cement and concrete; solution effects of water on, 1441
 natural; effects of, on pipe corrosion, 1298, 1303
 pipe; experience of various cities with, 1029
 pipe and tank; effects of, on water quality, 1
 Litigation; *see also* Legislation; Liability
 water rights; California board for adjudication of, 105
 Long Island, N.Y.; remote-control operation on, 1371
 Long lines; *see* Transmission lines
 Los Angeles, Calif.; comparison of earnings of water and power utilities at, 1126
 water demand trend in, 1055 (erratum, 1451)

M

- Machines; *see* Analyzers; Equipment
 Madison, Wis.; distribution system records and inspection at, 499
 well construction and maintenance at, 897
 Magnesium; effect of, on sludge calcining, 1343
 Maine; Portland Water District; study of hexametaphosphate for pipe scale control in, 1200
 Mains; *see* Distribution systems; Pipe; Pipelines
 Maintenance; meter; costs of, 1461
 pipelines, 810, 1029, 1200
 valves and hydrants, 913
 water works; 1955 data on costs of, 643
 wells, 817, 897
 Management; *see* Administration; Organization
 Manganese; sodium hexametaphosphate for stabilization of, 813
 Manitoba; Winnipeg; district operation at, 1389
 Maryland; *see also* Baltimore; Bel Air
 water use law in, 728
 Massachusetts; Billerica; liquid alum for coagulation at, 1331
 Membrane filters; AWWA policy on use of, as alternative to MPN procedure, 1530
 comparison of MPN method with, 1452
 quality control with; erratum, 26

- Meter reading; cost of, for indoor and outdoor installations, 1462
 Metering; 1955 data on, 616
 analysis of, 1545
 Meters; availability of AWWA standard for testing of, 936
 residential; sizing of, 1191
 various types of installations for, 1459
 Methane; proposed standard methods for determination of, 1077
 Michigan; *see also* Detroit; Kalamazoo; Lansing
 adequacy of water utility earnings in, 1113
 financing of water works improvements in, 859
 Microorganisms; *see* Aquatic organisms and growths; Bacteria
 Microphotometry; turbidity analysis by, 63
 Microstrainers; experience with, 541
 Milwaukee, Wis.; fluoridation experience at, 1239
 liquid alum for coagulation at, 52 (erratum, 276), 1321
 Missouri; *see* Kansas City
 Molecular filter membranes; *see* Membrane filters
 Most probable number; comparison of membrane filter method with, 1452
 confidence limits for, 1060
 Multiple-treatment units; automatic control of, 777

N

- National Board of Fire Underwriters; availability of new grading schedule of, 54
 New England; water use law in, 721
 New Jersey; *see also* Atlantic City
 photo of Raritan River in, *August cover*
 water supply development in, 969
 New Mexico; water supply problems in, 475
 New York, N.Y.; repair of spillway leaks at New Croton Dam of, 198
 New York State; *see* Long Island; New York; Newburgh; Rochester
 Newburgh, N.Y.; uniform concentration of fluoride at, 512
 Nitro, W.Va.; taste and odor problems at, 309
 Norfolk, Va.; main cleaning and lining at, 1037
 North Carolina; *see also* Charlotte; Greensboro
 water use law in, 724

O

- Oahu; geology of, 1404
 Oakland, Calif.; recreational use of watershed of, 1172

Odors; *see* Tastes and odors
 Ohio; *see also* Cincinnati; Cleveland; Findlay
 southwestern; industrial water supply system in, 313
 western; limestone and dolomite aquifers in, 464
 Oil hydrocarbons; measurement of small quantities of, 55
 Oklahoma City, Okla.; study of reservoir evaporation control at, 846
 Ontario; *see* Ottawa; Toronto
 Oregon; water law and resources in, 986
 Organization; *see also* Districts; Suburban areas
 San Diego County Authority; description of, 527
 Southwestern Ohio Water Company; description of, 313
 suburban area; study of, in North Carolina, 834
 water utility; problems of, in Great Britain, 1001
 1955 data on types of control in, 564
 Orsat method; methane determination by, 1081
 Ottawa, Ont.; meter installation practice at, 1473
 Outside-city service; *see* Suburban areas
 Ownership; water utility; analysis of 1955 operating data by type of, 1561
 Oxidation-reduction potentials; relation of, to iron removal, 1223

P

Paints; *see* Linings
 Palo Alto, Calif.; digital computer for distribution system study at, 523
 Pennsylvania; *see* Philadelphia
 Personnel; *see* Certification; Employees; Engineers; Health; Safety; Training
 Petroleum hydrocarbons; measurement of small quantities of, 55
 Philadelphia, Pa.; fluoridation experience at, 1239
 meter installation practice at, 1465
 network analyzer at, 15
 taste and odor control at, 205
 Phosphates; *see also* Hexametaphosphate poly-; evaluation of, for various uses, 1581
 Photometry; micro-; turbidity analysis by, 63

Pipe; *see also* Concrete pipe; Plastic pipe; Services; Steel pipe
 cast-iron; availability of revised manual for, 1278
 corrosion and tuberculation of, by Great Lakes water, 1294
 effect of natural coatings on corrosion of, 1298, 1303
 galvanized-iron; inhibition of corrosion of, by sodium silicate, 1432
 Pipelines; *see also* Distribution systems; Pipe
 cleaning and lining of, 1029
 court rulings on liability from breaks in, 1025
 evaluation of polyphosphate as aid in cleaning of, 1586
 1955 data on mileage of, 590
 analysis of, 1541
 repair of leak in, from inside, 1195
 sodium hexametaphosphate use in conjunction with cleaning of, 810
 transmission; considerations in design and construction of, 1359
 Pitting; *see* Corrosion
 Plastic pipe; experience with, 427 (erratum, 1312)
 Pollution; *see also* Radioactive wastes
 ground water; World Health Organization report on, 392
 oil; measurement of, 55
 synthetic-detergent; study of, 480, 1355
 tastes and odors due to, 1513
 underground waste disposal as cause of, 1334
 Portland Water District, Me.; study of hexametaphosphate for pipe scale control in, 1200
 Pressure; data on, for residential water fixtures, 1191
 distribution system; 1955 data on, 565
 analysis of, 1542
 Public relations; AWWA program for, 357
 construction projects, 791
 employee recruiting, 1281
 monthly billing, 1104
 rate increases, 151
 recreational use of reservoirs, 1160
 water quality complaints, 785
 Publications; AWWA; report on, 349
 Pumping stations; automatic and remote controls in, at Giddings, Tex., 47
 at Vancouver, Wash., 1387
 on Long Island, N.Y., 1371
 underground; design and construction of, 491

Pumps; 1955 data on types of power for, 565
submersible; applications of, 870
Purification; *see* Treatment; Treatment
plants

Q

Quality; river water; Illinois study of, 1213
tap water; handling of complaints about,
785
water; changing concepts of, 27
effects of pipe and tank linings on, 1
effects of rise in temperature on, 405
small-plant problems of, 929

R

Radioactive tracers; flow studies with, 743
Radioactive wastes; disposal of, 505
stream surveys for control of, 750
Radioactivity; environmental; monitoring of,
187
mixed-bed ion exchange for removal of,
1085
nuclear reactor; photo of, *June cover*
Radiocarbon; use of, in coliform-bacteria
tests, 1069
Radionuclides; procedures for identification
of, 767
Radiostrontium; absence of, in Wisconsin
strontium-bearing waters, 1497
Raritan River Basin; development projects
for, 974
photo of, *August cover*
Rates; bases for determination of, 165
determination of, for small water utilities,
923
differentials in, for high-demand control at
Kansas City, Mo., 705
1955 data on, 617
analysis of, 1547
relation of, to revenue, 1112, 1565
West Virginia Public Service Commission
jurisdiction over, 154
Wisconsin Public Service Commission
regulation of, 160
Recharge; control of sea water intrusion by,
75
1955 statistics on, 389
Reclamation Bureau; *see* Government (US)
Records; accounting; types of, for small
plants, 21
coliform test; simplification of, 457
distribution system; Madison, Wis., pro-
cedures for, 499

Red water; evaluation of polyphosphates for
prevention of, 1582
use of sodium hexametaphosphate for pre-
vention of, 813
Redox potentials; relation of, to iron re-
moval, 1223
Regulation; *see* Legislation
Repair; *see* Maintenance
Reprints; list of, 224, 282, 449, 790, 909,
1052, 1212, 1358, 1498, 1616
Reservoirs; *see also* Storage; Tanks
aquatic plants in, 318
distribution; underground; design of, 1499
impounding; acquisition and use of land
for, 1147
recreational use of, 1160
monomolecular film for control of evapo-
ration in, 397, 841
Resin; epoxy; use of, in leak repair, 1197
Resources; *see* Water resources
Revenue; *see also* Financing; Rates
adequacy of, 1112, 1565
comparisons of, for different types of utili-
ties, 1118
1955 data on, 642 (erratum, 1580)
analysis of, 1549
graph of, *December cover*
Revenue-producing water; procedures for
determining amount of, 1587
Richmond, Va.; meter installation practice
at, 1469
Rochester, N.Y.; cement lining of mains at,
1039

S

Safety; AWWA awards for, 339
measures for, in fluoride handling, 1242,
1250
off-the-job; need of program for, 1020
organization of program for, at Knox-
ville, Tenn., 937
record of, at Chicago, Ill., 940
rules for, in use of truck-mounted power
winches, 1076
Salt water demineralization; description of
processes for, 1007
Sampling; water; technique of, in radio-
activity studies, 754
San Diego County, Calif.; authority organi-
zation in, 525
conversion of irrigation systems to supply
potable water in, 531
photo of El Capitan Reservoir in, *May
cover*
water demand trend in, 1057 (erratum,
1451)

- San Francisco, Calif.; fluoridation experience at, 1239
- Scale; *see also* Corrosion
evaluation of polyphosphates for control of, 1583
evaluation of "water conditioner" units for control of, 1179 (erratum, 1477)
sodium phosphate for control of, 805, 1200
- Schools; *see* Certification; Training
- See water demineralization; description of processes for, 1007
- Sea water intrusion; study and control of, in California, 71
- Seattle, Wash.; recreational use of watershed of, 1169
- Sedimentation; *see* Coagulation
- Services; 1955 data on, 616 (erratum, 1580)
analysis of, 1545
rate differentials for various classes of, at Kansas City, Mo., 709
residential; sizing of, 1191
- Settling; *see* Coagulation
- Sheboygan, Wis.; fluoridation experience at, 1239
- Short schools; *see* Certification; Training
- Shortages; *see* Demand
- Silica; activated; use of, in treatment of textile-finishing water, 459 (erratum, 824)
- Silicate; sodium; inhibition of zinc corrosion by, 1432
- Silicofluoride; sodium; fluoridation experience with, 1239
- Sludge calcining; Lansing, Mich., process for, 327
study of, 1343
- Small plants; construction equipment for, 910
Illinois survey of training and duties of operators of, 887
rate schedules for, 923
records and accounts for, 21
water quality problems of, 929
- Sodium fluoride; fluoridation experience with, 1239
- Sodium hexametaphosphate; *see* Hexametaphosphate
- Sodium silicate; inhibition of zinc corrosion by, 1432
- Sodium silicofluoride; fluoridation experience with, 1239
- Softening; *see* Lime; Phosphates
- South Carolina; ground water resources in coastal plain of, 283 (errata, 456, 742)
- Specifications; *see* Standards
- Spectrophotometry; chloride determination by, 1485
strontium determination by, 1494
- Standard Methods; alternate; AWWA approval of membrane filter procedure as, 1530
proposed; for methane determination, 1077
- Standards; ASA; cast-iron pipe manual (ASA A21.1, AWWA C101); availability of revised edition of, 1278
AWWA; change in nomenclature of, 992
meter testing (C705); availability of, 936
steel pipe coatings (C203); new edition of, 941
steel pipe joints (C206); revision of, 312
- Standpipes; *see* Tanks
- Statistics; artificial recharge, 389
certification, 1292
fluoridation; 1955; US and Canada, 41
1956; US and Canada, 1478
election results, 40
reservoir land areas, 1157
taste and odor control, 1510
treatment facilities; 1955 USPHS survey, 1567
water use, 168, 225, 369
areal, 1054 (erratum, 1451)
water works operation; 1955 data on, 553 (erratum, 1580)
analysis of, 1531
- Steel pipe; new edition of AWWA standard on coatings for, 941
revision of standard on joints for, 312
use of, for transmission lines, 1360
- Sterilization; *see* Chlorination; Chlorine
- Storage; *see also* Reservoirs; Tanks
distribution; 1955 data on, 565
analysis of, 1540
provision of, for peak demands, 263
terminal; transmission line; economics of, 1365
upland; design and construction of, 277
- Stream pollution; *see* Pollution
- Strontium; content of, in Wisconsin municipal supplies, 1493
- Suburban areas; *see also* Districts
Cincinnati, Ohio; water supply for, 322
costs of water systems for, 1139
Greensboro, N.C.; study of water needs of, 834
Kansas City, Mo.; rates for, 705
Michigan; methods of financing water works improvements in, 859
- Supply; *see* Development; Salt water demineralization; Water resources
- Synthetic detergents; British and American research on, 1355
study of biological oxidation of, 480, 1356

T

- Tampa, Fla.: stationary chlorine storage facilities at, 223
- Tanks; *see also* Storage
effects of linings of, on water quality, 1
elevated; survival of, in Kansas City, Mo., tornado, *October cover*, 1313
- Tastes and odors; *see also* Aquatic organisms and growths
control of, at Nitro and Charleston, W.Va., 309
at Philadelphia, Pa., 205
in Canada, 1525
detection and measurement of, 1514
handling of complaints about, 785
survey of problems and measures for control of, 1507
- Taxes; publicly owned utility; Wisconsin policy on, 1369
water utility; 1955 data on, 643
analysis of, 1554
- Telemetering; *see* Equipment (control)
- Temperature; effect of rise in, on water quality and treatment, 405
water; 1955 data on, 565
analysis of, 1542
- Tennessee; *see* Knoxville
- Testing; coagulation; jar, 144, 1425
fire flow, 779
meter; availability of AWWA standard for, 936
steel pipe coating; AWWA standard for, 947
tastes and odors, 1514
wells, 443
- Texas; *see* Dallas; Fort Worth; Giddings; Houston
- Toronto, Ont.; underground distribution reservoirs at, 1499
- Tracers; radioactive and chemical; flow studies with, 743
- Training; in-service; programs for, 1290
need for, 1283, 1288
small-plant operator; Illinois survey of, 887
- Transmission lines; considerations in design and construction of, 1359
1955 data on mileage of, 590
- Treatment; *see also* Chlorination; Coagulation; Filtration; Multiple-treatment units; Tastes and odors
automatic and remote control of, 775, 1378
Canadian practices in, 1522
1955 data on types of, 564
USPHS 1955 survey of facilities for, 1567
- Treatment plants; design aspects of, 413

- Tuberculation; *see* Corrosion; Scale
- Turbidity; measurements of, as jar test criteria, 1425
microphotometric analysis of, 63

U

- Unaccounted-for water; 1955 data on, 591
analysis of, 1537
procedures for determining and reducing amount of, 1587
- Underdrains; filter; precast concrete for, 450
- United Nations; World Health Organization; report of, on ground water pollution, 392
- United States; *see* Government
- Use; *see* Consumption; Demand

V

- Valves; automatic; operation of, 301
butterfly; design and application of, 772
installation and maintenance of, at Wilmette, Ill., 913
1955 data on, 590
analysis of, 1540
- Vancouver, Wash.; distribution system remote control at, 1387
- Virginia; *see also* Alexandria; Brookneal; Danville; Norfolk; Richmond
survey of water resources problems in, 68
water rights law in, 717

W

- Washington; *see* Seattle; Vancouver
- Washington, D.C.; fluoridation experience at, 1239
liquid alum for coagulation at, 1330
- Wastes; *see* Pollution; Radioactive wastes
- "Water conditioner" units; evaluation of performance of, 1179 (erratum, 1477)
- Water districts; *see* Districts
- Water resources; *see also* Development; Salt water demineralization
AWWA statement on national policy on, 825
Oregon; legislation on, 986
state laws on use of, 717, 721
state studies on, 68
summary of various commission studies on, 712, 825
- Water works; *see also* Small plants; Treatment plants
1955 operating data for, 553 (erratum, 1580)
analysis of, 1531
- Water works administration; report of committee on, 331

Water works practice; report of committee on, 341 (erratum, 391)

Watersheds; *see* Development; Reservoirs; Water resources

Weeds; *see* Aquatic organisms and growths

Well pumps; underground installation of, 491

Wells; *see also* Ground water; Recharge construction, maintenance, and redevelopment of, 817, 897
design and rating of, 439

West Virginia; *see also* Burnsville, Charleston; Nitro
rate regulation in, 154

Wilmette, Ill.; valve and hydrant maintenance at, 913

Winches; power; truck-mounted; safe use of, 1076

Winnipeg, Man.; district operation at, 1389

Wisconsin; *see also* Madison; Milwaukee; Sheboygan

analysis of 1955 survey data for utilities in, 1560

publicly owned utility taxation in, 1369, 1560

rate regulation in, 160

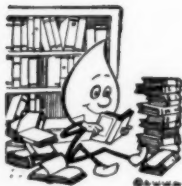
strontium content of municipal supplies in, 1493

World Health Organization; report of, on ground water pollution, 392

Z

Zinc; inhibition of corrosion of, by sodium silicate, 1432

Pagination: Jan. 1-88; Feb. 89-224; Mar. 225-368; Apr. 369-504; May 505-696; Jun. 697-824
Jul. 825-968; Aug. 969-1106; Sep. 1107-1238; Oct. 1239-1370; Nov. 1371-1506; Dec. 1507-1638



Author Index

- ADAMS, REGINALD B.; comparison of standard dilution and membrane filter methods, 1452
- AGNEW, A. VINCENT; advantages of monthly billing for water utilities, 1103
- ALDRICH, ELLWOOD H.; automation in recent water purification plants, 775
- ALLEN, BRUCE F.; the California water plan and its administration—financing the plan, 121
- ALLEN, E. JERRY; public access to lands surrounding impounding reservoirs—Seattle watershed access policy, 1169
- APPLEYARD, VICTOR A. & LINAWEAVER, FRANK P., JR.; the McIlroy fluid analyzer in water works practice, 15
- ARNOLD, GERALD E.; recent meter-setting developments—Philadelphia, 1465
- BAER, BEN K.; preparing for a rate increase—legal aspects, 156
- BAILEY, ALBION A.; *panel discussion*—experience in applying fluorides, 1244, 1251, 1256, 1265
- BANKS, HARVEY O.; the California water plan and its administration—the program of the Department of Water Resources, 99
- BANKS, HARVEY O.; RICHTER, RAYMOND C.; & HARDER, JAMES; sea water intrusion in California, 71
- BARRON, DONALD W.; stray-current corrosion of underground distribution systems, 881
- BARRY, JAMES E.; applications of submersible pumps, 870
- BARTSCH, ALFRED F. (with COOKE, INGRAM & ENRIGHT); submerged aquatic plants in a primary settling reservoir, 318
- BAUMANN, E. ROBERT; diatomite filters for municipal installations, 174; *erratum*, 438
- BAUMANN, E. ROBERT (with SEIDEL); a statistical analysis of water works data for 1955, 1531
- BAUMER, WILLIAM H.; *panel discussion*—New Jersey water supply development, 973
- BAYLIS, JOHN R.; *panel discussion*—experience in applying fluorides, 1239, 1246, 1252, 1259, 1276
- BEADLE, BUELL W. & CRUSE, ROBERT R.; water conservation through control of evaporation, 397
- BEAN, ELWOOD L.; taste and odor control at Philadelphia, 205
- BEAN, ELWOOD L.; *panel discussion*—experience in applying fluorides, 1245, 1251, 1256, 1266
- BECHERT, CHARLES H. (with HERT); *discussion*—water resources problems in Virginia, 70
- BEERMANN, PAUL & HOLMGREN, RICHARD S.; meeting increasing demands in San Diego County, Calif., 525
- BELLACK, ERVIN (with MAIER); fluorspar for fluoridation, 34
- BERRY, WILLIAM L.; the California Water Plan and its administration—local authorities' part, 115
- BINNIE, GEOFFREY M.; water works planning in Great Britain, 1001
- BLACK, A. L. (with BLACK, BUSWELL & EIDNESS); review of the jar test, 1414
- BLACK, A. P.; BUSWELL, ARTHUR M.; EIDNESS, FRED A.; & BLACK, A. L.; review of the jar test, 1414
- BLACK, A. P. (with EIDNESS); carbonation of water softening plant sludge, 1343
- BLACK, A. P.; *panel discussion*—experience in applying fluorides, 1270
- BLACK, R. D.; growing use of water for irrigation in Illinois, 537
- BOOKMAN, MAX; urban water requirements in California, 1053; *erratum*, 1451
- BROWN, STRATTON S.; *panel discussion*—financing water works improvements in Michigan, 866
- BROWNLEY, FLOYD L., JR. & SELLERS, EDGAR E.; new method for fluoride determination, 1234
- BRUNSTEIN, MAURICE & LONG, JAMES S.; repairing a water main from the inside, 1195
- BUBBIS, NATHAN S.; future developments in the Greater Winnipeg Water District, 1389
- BURNETT, J. L. & RODDY, CHARLES P.; inspecting and testing stationary chlorine storage facilities, 223

Pagination: Jan. 1-88; Feb. 89-224; Mar. 225-368; Apr. 369-504; May 505-696; Jun. 697-824; Jul. 825-968; Aug. 969-1106; Sep. 1107-1238; Oct. 1239-1370; Nov. 1371-1506; Dec. 1507-1638

- BURZELL, LINDEN R.; growth and conversion of water systems in San Diego County, Calif., 531
- BUSWELL, ARTHUR M. (with BLACK, EIDSNESS & BLACK); review of the jar test, 1414
- BYERRUM, R. U. (with MacKENZIE & HOPPERT); studies of cadmium and chromium solubility and toxicity, 1310
- CAPEN, CHARLES H.; *panel discussion*—New Jersey water supply development, 979
- CARNS, JAMES G., JR.; recent meter-setting developments—indoor or outdoor installations?, 1460
- CASSIDY, WILLIAM F.; the California Water Plant and its administration—flood control problems, 126
- CHASE, E. SHERMAN; *discussion*—land policy for impounding reservoirs, 1156
- COFFMAN, PAUL A., JR.; automation and remote control of chemical feeders, 1378
- COHEN, JESSE M.; improved jar test procedure, 1425
- COLE, E. SHAW (*chairman*); revenue-producing versus unaccounted-for water, 1587
- COLL, HANS (with WEST); direct spectrophotometric determination of chloride ion in water, 1485
- CONLEY, W. R. & PITMAN, R. W.; microphotometer turbidity analysis, 63
- CONOVER, CLYDE S.; municipal water supplies in New Mexico, 475
- COOKE, WILLIAM BRIDGE; INGRAM, WILLIAM MARCUS; BARTSCH, ALFRED F.; & ENRIGHT, J. DANIEL; submerged aquatic plants in a primary settling reservoir, 318
- COSENS, KENNETH W.; precast concrete rapid sand filter underdrain, 450
- CRABILL, MARSHALL P.; *panel discussion*—experience in applying fluorides, 1272
- CRUSE, ROBERT R. (with BEADLE); water conservation through control of evaporation, 397
- DOWNER, WILLIAM J.; certification of water works operators in Illinois, 890
- EGBERT, DONALD C.; *panel discussion*—financing water works improvements in Michigan, 859
- EIDSNESS, FRED A. & BLACK, A. P.; carbonation of water softening plant sludge, 1343
- EIDSNESS, FRED A. (with BLACK, BUSWELL & BLACK); review of the jar test, 1414
- ELIASSEN, R. & SKRINDE, R. T.; experimental evaluation of "water conditioner" performance, 1179; *erratum*, 1477
- END, WILLIAM F., JR.; automation and the automatic valve, 301
- ENRIGHT, J. DANIEL (with COOKE, INGRAM & BARTSCH); submerged aquatic plants in a primary settling reservoir, 318
- ERICKSON, CLAUD R.; an evaluation of water utility earnings—Michigan, 1113
- ERICKSON, CLAUD R. & WRIGHT, RALPH C.; maintenance of rock wells, 817
- ESSER, GEORGE H., JR.; municipal utilities and the fringe area, 834
- ETTINGER, M. B. (with LUDZACK); biological oxidation of hexadecanol under laboratory conditions, 849; *erratum*, 1178
- EVANS, GEORGE R.; review of experiences with microstrainer installations, 541
- FAUST, RAYMOND J.; in-service training and certification, 1288
- FITZGERALD, ROBERT W.; cleaning and relining small mains—cleaning and relining at Norfolk, 1037
- FLENTJE, MARTIN E. & SWEITZER, ROBERT J.; further study of solution effects on concrete and cement in pipe, 1441
- FOERSTER, WILLIAM K.; construction equipment for small water utilities, 910
- FORD, ARTHUR C.; repairs of spillway leaks at New Croton, N.Y., 198
- FORDE, A. V. (with MATHESON); survey of water purification practice in Canada, 1522
- FREESE, SIMON W.; peak demand storage, 263
- FRIEL, FRANCIS S.; land policy for impounding reservoirs, 1147
- GARSTKA, W. U. (with TIMBLIN & MORAN); use of monomolecular layers for reservoir evaporation reduction, 841
- GERSTEIN, HYMAN H.; impact of water use for air conditioning on Chicago's water system, 697
- GOLDIN, ABRAHAM S. (with KAHN); radiochemical procedures for the identification of the more hazardous nuclides, 767
- GRAESER, HENRY J.; an evaluation of water utility earnings—Dallas, 1115
- GRAESER, HENRY J.; *discussion*—land policy for impounding reservoirs, 1158

- GRANT, BURTON S.; an evaluation of water utility earnings—Los Angeles, 1126
- GRANT, J. WALLACE; rebuilding a small public water system, 148
- GRIFFIN, ATTMORE E.; *panel discussion*—experience in applying fluorides, 1257
- GROOT, JOHN J.; water law in eastern United States—Delaware, 731
- GULLANS, OSCAR; *panel discussion*—techniques in the use of liquid alum, 1322
- HAGEE, G. RICHARD (*with* STRAUB); radioactive tracers in sanitary engineering, 743
- HALEY, JESS L.; records and accounts for small systems, 21
- HANEY, PAUL D. (*chairman*); effects of synthetic detergents on water supplies, 1355
- HANNA, HOMER W., JR.; preparing for a rate increase—PSC viewpoint, 154
- HARDENBERGH, W. A.; recruiting and training of personnel, 1283
- HARDER, JAMES (*with* BANKS & RICHTER); sea water intrusion in California, 71
- HARRISON, JOHN D.; *panel discussion*—financing water works improvements in Michigan, 860
- HARRISON, VENTON R. (*with* LEVIN & HESS); use of radioactive culture media, 1069
- HARVILL, CLYDE R.; some details of water treatment plant design, 413
- HARWARD, ERNEST D. (*with* TSIVOGLOU & INGRAM); stream surveys for radioactive waste control, 750
- HATCHER, MELVIN P.; high-demand restriction at Kansas City, Mo., 705
- HAWKINS, EDGAR M., JR.; an evaluation of water utility earnings—Danville, Va., 1130
- HAYNES, LAWSON; treatment of industrial water pollution at Nitro and Charleston, W.Va., 309
- HEGGIE, GLEN D.; effects of sprinkling restrictions, 267
- HERT, ORAL H. & BECHERT, CHARLES H.; *discussion*—water resources problems in Virginia, 70
- HESS, WALTER C. (*with* LEVIN & HARRISON); use of radioactive culture media, 1069
- HOAG, LYLE N. & WEINBERG, GERALD; pipeline network analysis by electronic digital computer, 517
- HOLMES, HENRY B., JR.; national and local aspects of water resources problems, 712
- HOLMGREN, RICHARD S. (*with* BEERMANN); meeting increasing demands in San Diego County, Calif., 525
- HOLSINGER, HENRY; the California Water Plan and its administration—program of the Water Rights Board, 105
- HOPPERT, C. A. (*with* MACKENZIE & BYERUM); studies of cadmium and chromium solubility and toxicity, 1310
- HOWLAND, WALLACE; the California Water Plan and its administration—legal questions to be answered, 135
- HOWSON, LOUIS R.; an evaluation of water utility earnings—introduction, 1112
- HOWSON, LOUIS R.; factors affecting long-distance transmission of water, 1359
- HOWSON, LOUIS R. (*chairman*); report of the committee on water works practice, 341; *erratum*, 391
- HUDSON, HERBERT E., JR.; flocculation and flocculation aids, 242
- ILLIG, GEORGE L., JR.; glassy phosphates in water treatment, 805
- INGRAM, WILLIAM MARCUS (*with* COOKE, BARTSCH & ENRIGHT); submerged aquatic plants in a primary settling reservoir, 318
- INGRAM, WILLIAM MARCUS (*with* TSIVOGLOU & HARWARD); stream surveys for radioactive waste control, 750
- JACKSON, NORMAN E.; *panel discussion*—techniques in the use of liquid alum, 1315, 1330
- JACOBY, HOWARD; application of electronics to the water supply industry, 1043
- JENKINS, DAVID S.; developments in saline water conversion, 1007
- JOHNSON, WILLIAM M.; water resources problems in Virginia, 68
- JOHNSTON, CARL B.; water quality problems in small water works systems, 929
- JONES, GERALD W.; construction and public relations, 791
- JORDAN, HARRY E.; *discussion*—water works planning in Great Britain, 1005
- JORDAN, HARRY E.; *discussion*—advantages of monthly billing for water utilities, 1106
- KABLER, PAUL W. (*with* THOMAS & WOODWARD); use of molecular filter membranes for water potability control; *erratum*, 26

- KAHN, BERND & GOLDIN, ABRAHAM S.; radiochemical procedures for the identification of the more hazardous nuclides, 767
- KENDALL, NATHANIEL J.; engineers in short supply, 469
- KERSLAKE, JAMES E.; liquid alum at Milwaukee, 52; *erratum*, 276
- KERSLAKE, JAMES E.; *panel discussion*—experience in applying fluorides, 1246, 1251, 1257, 1267
- KERSLAKE, JAMES E.; *panel discussion*—techniques in the use of liquid alum, 1321
- KIKER, JOHN E.; specialty board certification for sanitary engineers, 191
- KINGMAN, DEAN S.; underground pumping stations, 491
- KRASauskas, JOHN W.; *panel discussion*—experience in applying fluorides, 1242, 1248
- KRASauskas, JOHN W.; *discussion*—environmental radiological monitoring, 189
- KRAUSE, FRED; value of sludge calcining, 327
- KURANZ, ARTHUR P.; Wisconsin's policy on municipal utility taxation, 1369
- LADUE, WENDELL R. (*chairman*); report of the committee on water works administration, 331
- LARSON, BERNT O. (*with* LARSON); mineral quality of Illinois rivers, 1213
- LARSON, THURSTON E.; evaluation of the use of polyphosphates in the water industry, 1581
- LARSON, THURSTON E. & LARSON, BERNT O.; mineral quality of Illinois rivers, 1213
- LARSON, THURSTON E. & SKOLD, R. V.; corrosion and tuberculation of cast iron, 1294
- LEARNED, ALBERT P.; determination of municipal water rates, 165
- LEARNED, ALBERT P.; rate making for small water works, 923
- LEFEBER, ALFRED; factors limiting financing of new water works construction, 1593
- LEHRMAN, LEO (*with* SHULDENER); influence of bicarbonate ion on inhibition of corrosion by sodium silicate in a zinc-iron system, 1432
- LEVIN, GILBERT V.; HARRISON, VENTON R.; & HESS, WALTER C.; use of radioactive culture media, 1069
- LEWIS, ROBERT C.; water supply for large industries, 313
- LINAWEAVER, FRANK P., JR. (*with* APPLE-YARD); the McIlroy fluid analyzer in water works practice, 15
- LINDEEN, LEONARD F.; installation and maintenance of valves and hydrants at Wilmette, Ill., 913
- LINDGREN, CARL-GUSTAV; measurement of small quantities of hydrocarbon in water, 55
- LINDSTEN, DON C. (*with* LOWE); environmental radiological monitoring, 187
- LONG, JAMES S. (*with* BRUNSTEIN); repairing a water main from the inside, 1195
- LOVE, CLAUDE L.; water law in eastern United States—North Carolina and other Atlantic States, 721
- LOWE, HARRY N., JR. & LINDSTEN, DON C.; environmental radiological monitoring, 187
- LUDZACK, F. J. & ETtinger, M. B.; biological oxidation of hexadecanol under laboratory conditions, 849; *erratum*, 1178
- LURIE, DAVID; *panel discussion*—techniques in the use of liquid alum, 1318
- MACDONALD, CECIL C.; preparing for a rate increase—utility viewpoint, 151
- MACDONALD, W. ELWOOD; recent meter-setting developments—Ottawa, 1473
- MACE, HAROLD H.; a water supply for suburban Cincinnati, 322
- MACKENZIE, ROBERT D.; HOPPERT, C. A.; & BYERRUM, R. U.; studies of cadmium and chromium solubility and toxicity, 1310
- MACKICHAN, KENNETH A.; estimated use of water in the United States, 369
- MAIER, FRANZ J. & BELLACK, ERVIN; fluor-spar for fluoridation, 34
- MAIER, FRANZ J. (*chairman*); study of permanent color comparator kits for fluorides, 417
- MARGRAVE, GERALD E. (*with* WEART); oxidation-reduction potential measurements applied to iron removal, 1223
- MATHESON, DeLOSS H. & FORDE, A. V.; survey of water purification practice in Canada, 1522
- MATHEWS, C. M.; factors to be considered in house piping sizes and selection of meters, 1191
- McCAULEY, ROBERT F.; protective coatings for water distribution systems, 1303
- McFarland, JOHN W.; the California Water Plan and its administration—where should local authorities take the initiative?, 111

- McFARLAND, JOHN W.; public access to lands surrounding impounding reservoirs—East Bay District policy, 1172
- McGUIRE, M. H. & MERRYFIELD, FRED; an evaluation of water utility earnings—adequacy of earnings, 1133
- McKEE, JACK E.; changing concepts of water quality, 27
- McKELVEY, GEORGE I., JR.; present bond market status, 1107
- McLENDON, SAMUEL C. & ZIHAI, MICHAEL; telemetering and remote control by the Long Island Water Corporation, 1371
- McNALL, DOROTHY R. (*with* NICHOLS); strontium content of Wisconsin municipal waters, 1493
- MEDBERY, H. CHRISTOPHER; *panel discussion*—experience in applying fluorides, 1243, 1250, 1254, 1264
- MERRYFIELD, FRED; review of Oregon water law, 986
- MERRYFIELD, FRED (*with* McGUIRE); an evaluation of water utility earnings—adequacy of earnings, 1133
- MEYNER, ROBERT B.; *panel discussion*—New Jersey water supply development, 969
- MIDDLEBROOKS, E. JOE & WALTON, GRAHAM; recording bacteriological data, 457
- MILAM, T. RILEY; development of a rural public water supply—Gainesville, Ga., experience, 1145
- MILLER, LYNN M.; design and rating of wells and well fields, 439
- MILLER, LYNN M. (*chairman*); underground waste disposal and control, 1334
- MONTE, WILLIAM D. & SCALES, HAROLD B.; maintaining pipeline flow capacity after cleaning, 1200
- MORAN, W. T. (*with* TIMBLIN & GARSTKA); use of monomolecular layers for reservoir evaporation reduction, 841
- MORGAN, EDWARD J.; Honolulu water supply, 1403
- MORRIS, SAMUEL B.; the California Water Plan and its administration—California is listening, 89; summary, 142
- MORSE, DANIEL P.; public access to lands surrounding impounding reservoirs—recreational use in Indianapolis, 1160
- MOSLEY, EARL L.; western slope water development in Denver, 251
- MURDOCH, JOHN H., JR.; court opinions on pipeline breaks, 1025
- MURRAY, WILLIAM BRUCE; automatic chlorination control by continuous remote residual determination, 795
- NELSON, FREDERICK G.; *discussion*—carbonation of water softening plant sludge, 1351
- NESIN, BENJAMIN C.; *panel discussion*—experience in applying fluorides, 1252, 1268
- NICHOLS, M. STARR & McNALL, DOROTHY R.; strontium content of Wisconsin municipal waters, 1493
- NORDNESS, ELMER L.; distribution controls at Madison, Wis., 499
- NORDNESS, ELMER L.; developments in well production and maintenance—Madison, Wis., 897
- NORRIS, STANLEY E.; characteristics of limestone and dolomite aquifers in western Ohio, 464
- OCKERSHAUSEN, RICHARD W.; *panel discussion*—techniques in the use of liquid alum, 1316
- O'LEARY, HENRY J.; determination of water rates in Wisconsin, 160
- PALIN, ARTHUR T.; the determination of free and combined chlorine in water by the use of diethyl-*p*-phenylene diamine, 873
- PATTERSON, ALLAN B.; design of underground storage reservoirs, 1499
- PENDLETON, WENDELL; water law in eastern United States—Iowa, 733
- PHILLIPS, ROBERT S.; *panel discussion*—experience in applying fluorides, 1259, 1276
- PHILLIPS, ROBERT S. (*chairman*); status of fluoridation in the United States and Canada [1955], 41
- PHILLIPS, ROBERT S. (*chairman*); status of fluoridation in the United States and Canada [1956], 1478
- PITMAN, R. W. (*with* CONLEY); microphotometer turbidity analysis, 63
- PORGES, RALPH; summary of 1955 USPHS survey of treatment facilities in communities of 25,000 and over, 1567
- POWELL, SHEPPARD T.; *discussion*—developments in saline water conversion, 1018
- POWERS, HAROLD J.; the California Water Plan and its administration—water problem for the legislature, 92
- PRISLEY, FREDERIC A.; use of activated silica in water for textile finishing, 459; *erratum*, 824
- RENN, CHARLES E.; warm-water effects on municipal supplies, 405

- RICHTER, RAYMOND C. (with BANKS & HARDER); sea water intrusion in California, 71
- ROBERTS, J. MORAN; development of a rural public water supply—limited service to partially developed areas, 1139
- ROBINSON, THOMAS E.; air conditioning expansion and regulation, 217
- RODDY, CHARLES P. (with BURNETT); inspecting and testing stationary chlorine storage facilities, 223
- ROSEN, MILTON; problems in personnel recruiting, 1279
- ROSSUM, JOHN R. (chairman); proposed standard methods for methane determination, 1077
- ROWLAND, WALTER F.; duties and qualifications of operators of small water works, 887
- RYCKMAN, DEVERE W. (with SAWYER); anionic synthetic detergents and water supply problems, 480
- SABO, PAUL; developments in well production and maintenance—Kalamazoo, Mich., 905
- SASMAN, ROBERT T. (with SMITH); developments in well production and maintenance—Illinois, 903
- SAWYER, CLAIR N. & RYCKMAN, DEVERE W.; anionic synthetic detergents and water supply problems, 480
- SCALES, HAROLD B. (with MONIE); maintaining pipeline flow capacity after cleaning, 1200
- SCHARFF, SAMUEL A.; discussion—application of electronics to the water supply industry, 1049
- SCHROEDER, MARVIN H.; electrical supervisory controls at Vancouver, Wash., 1387
- SCHWEMLER, FRANK J.; cleaning and relining small mains—reconditioning water mains at Cleveland, 1029
- SCHWENK, HENRY C.; butterfly valve design and application, 772
- SEIDEL, HARRIS F. & BAUMANN, E. ROBERT; a statistical analysis of water works data for 1955, 1531
- SELLERS, EDGAR E. (with BROWNLEY); new method for fluoride determination, 1234
- SHANNON, ALBERT M. (with WALLACE); investigation and handling of water quality complaints, 785
- SHELTON, M. J.; need for planning in utilizing water resources, 993
- SHULDENER, HENRY L. & LEHRMAN, LEO; influence of bicarbonate ion on inhibition of corrosion by sodium silicate in a zinc-iron system, 1432
- SIGWORTH, E. A.; control of odor and taste in water supplies, 1507
- SINGEWALD, JOSEPH T., JR.; water law in eastern United States—Maryland, 728
- SIPLE, GEORGE E.; ground water in the South Carolina coastal plain, 283; *errata*, 456, 742
- SKOLD, R. V. (with LARSON); corrosion and tuberculation of cast iron, 1294
- SKRINDE, R. T. (with ELIASSEN); experimental evaluation of "water conditioner" performance, 1179; *erratum*, 1477
- SMITH, HARMON F. & SASMAN, ROBERT T.; developments in well production and maintenance—Illinois, 903
- SMITH, JOHN C.; panel discussion—experience in applying fluorides, 1241, 1252, 1260
- SMITH, LEWIS B.; cleaning and relining small mains—installing cement linings at Rochester, 1039
- SMITH, MARSDEN C.; recent meter-setting developments—Richmond, Va., 1469
- SOCHA, MAX K.; plastic pipe in water supply use—installation methods in Los Angeles, 427; *erratum*, 1312
- SOPP, GEORGE C.; off-the-job safety programs, 1020
- SPAULDING, JOHN N.; plastic pipe in water supply use—domestic water system uses, 433
- SPENCER, CLYDE H.; the California Water Plan and its administration—federal service and the plan, 132
- STRAUB, CONRAD P. & HAGEE, G. RICHARD; radioactive tracers in sanitary engineering, 743
- SWEITZER, ROBERT J. (with FLENTJE); further study of solution effects on concrete and cement in pipe, 1441
- SWOPE, H. GLADYS; mixed bed ion exchange for the removal of radioactivity, 1085
- TATNALL, GEORGE; procedure and interpretation of fire flow tests, 779
- TAYLOR, E. WINDLE; discussion—review of experiences with microstrainer installations, 549
- TAYLOR, FLOYD B.; uniformity of fluoride ion concentration in Newburgh, N.Y., distribution system, 512

- THOMAS, HAROLD A., JR.; WOODWARD, RICHARD L.; & KABLER, PAUL W.; use of molecular filter membranes for water potability control; *erratum*, 26
- TIMBLIN, LLOYD O., JR.; MORAN, W. T.; & GARSTKA, W. U.; use of monomolecular layers for reservoir evaporation reduction, 841
- TOLER, RICHARD A.; automatic controls in pumping stations at Giddings, Tex., 47
- TSIVOGLU, ERNEST C.; HARWARD, ERNEST D.; & INGRAM, WILLIAM MARCUS; stream survey for radioactive waste control, 750
- VOGT, JOHN E.; *panel discussion*—financing water works improvements in Michigan, 862
- WALLACE, WILLIAM M. & SHANNON, ALBERT M.; investigation and handling of water quality complaints, 785
- WALTON, GRAHAM (*with* MIDDLEBROOKS); recording bacteriological data, 457
- WEART, JAMES G. & MARGRAVE, GERALD E.; oxidation-reduction potential measurements applied to iron removal, 1223
- WEINBERG, GERALD (*with* HOAG); pipeline network analysis by electronic digital computer, 517
- WEIR, PAUL; effects of pipe and tank lining on water quality at Atlanta, 1
- WEIR, W. VICTOR; recent meter-setting developments—introduction, 1459
- WEST, PHILIP W. & COLL, HANS; direct spectrophotometric determination of chloride ion in water, 1485
- WHITAKER, MARK B.; organizing a safety program, 937
- WHITAKER, MARK B.; an evaluation of water utility earnings—Knoxville, 1135
- WILLIAMS, LEON G.; water supply from upland storage, 277
- WILLIS, M. JOSEPH; forecasting water requirements for distribution systems—forecasting industrial requirements, 235
- WOJCIK, JEROME B.; forecasting water requirements for distribution systems—forecasting residential requirements, 225
- WOLMAN, ABEL; disposal of radioactive wastes, 505
- WOLMAN, ABEL; basic principles of a national water resources policy—preamble, 825
- WOODWARD, RICHARD L.; how probable is the most probable number?, 1060
- WOODWARD, RICHARD L. (*with* THOMAS & KABLER); use of molecular filter membranes for water potability control; *erratum*, 26
- WRIGHT, RALPH C. (*with* ERICKSON); maintenance of rock wells, 817
- YACKEY, HAROLD H.; plastic pipe in water supply use—progress in plastics, 434
- ZIHAL, MICHAEL (*with* McLENDON); telemetering and remote control by the Long Island Water Corporation, 1371
- ZUFELT, JEROME C.; *panel discussion*—experience in applying fluorides, 1251, 1255, 1264

Jul. 825-968; Aug. 969-1106; Sep. 1107-1238; Oct. 1239-1370; Nov. 1371-1506; Dec. 1507-1638

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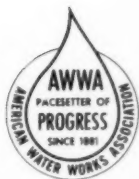
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Table of Contents

January

Effects of Pipe and Tank Lining on Water Quality at Atlanta.....	PAUL WEIR	1
The McIlroy Fluid Analyzer in Water Works Practice	VICTOR A. APPELYARD & FRANK P. LINAWEAVER JR.	15
Records and Accounts for Small Systems.....	JESS L. HALEY	21
Correction—Molecular Filter Membranes (THOMAS, WOODWARD & KABLER).....		26
Changing Concepts of Water Quality.....	JACK E. MCKEE	27
Fluorspar for Fluoridation.....	FRANZ J. MAIER & ERVIN BELLACK	34
Fluoridation Statistics in 1956.....		40
Status of Fluoridation in the United States and Canada.....	TASK GROUP REPORT	41
Automatic Controls in Pumping Stations at Giddings, Tex.	RICHARD A. TOLER	47
Liquid Alum at Milwaukee.....	JAMES E. KERSLAKE	52
Fire Underwriters Grading Schedule Available.....		54
Measurement of Small Quantities of Hydrocarbon in Water..	CARL-GUSTAV LINDGREN	55
Microphotometer Turbidity Analysis.....	W. R. CONLEY & R. W. PITMAN	63
Water Resources Problems in Virginia.....	WILLIAM M. JOHNSON	68
Discussion.....	ORAL H. HERT & CHARLES H. BECHERT	70
Sea Water Intrusion in California	HARVEY O. BANKS, RAYMOND C. RICHTER & JAMES HARDER	71

February

The California Water Plan and Its Administration		
California Is Listening.....	SAMUEL B. MORRIS	89
Water Problem for the Legislature.....	HAROLD J. POWERS	92
The Program of the Department of Water Resources.....	HARVEY O. BANKS	99
Program of the Water Rights Board.....	HENRY HOLSINGER	105
Where Should Local Authorities Take the Initiative?.....	JOHN W. MCFARLAND	111
Local Authorities' Part.....	WILLIAM L. BERRY	115
Financing the Plan.....	BRUCE F. ALLEN	121
Flood Control Problems.....	WILLIAM F. CASSIDY	126
Federal Service and the Plan.....	CLYDE H. SPENCER	132
Legal Questions to Be Answered.....	WALLACE HOWLAND	135
Summary.....	SAMUEL B. MORSE	142
Rebuilding a Small Public Water System.....	J. WALLACE GRANT	148
Preparing for a Rate Increase		
Utility Viewpoint.....	CECIL C. MACDONALD	151
PSC Viewpoint.....	HOMER W. HANNA	154
Legal Aspects.....	BEN K. BAER	156
Determination of Water Rates in Wisconsin.....	HENRY J. O'LEARY	160
Determination of Municipal Water Rates.....	ALBERT P. LEARNED	165
Diatomite Filters for Municipal Installations.....	E. ROBERT BAUMANN	174
Environmental Radiological Monitoring.....	HARRY N. LOWE JR. & DON C. LINDSTEN	187
Discussion.....	JOHN W. KRASAUSKAS	189
Specialty Board Certification for Sanitary Engineers.....	JOHN E. KIKER	191
Repairs of Spillway Leaks at New Croton, N.Y.	ARTHUR C. FORD	198
Taste and Odor Control at Philadelphia.....	ELWOOD L. BEAN	205

TABLE OF CONTENTS

iii

Air Conditioning Expansion and Regulation.....	THOMAS B. ROBINSON	217
Inspecting and Testing Stationary Chlorine Storage Facilities	J. L. BURNETT & CHARLES P. RODDY	223
Reprints Available		224

March

Forecasting Water Requirements for Distribution Systems		
Forecasting Residential Requirements.....	JEROME B. WOLFF	225
Forecasting Industrial Requirements.....	M. JOSEPH WILLIS	235
Flocculation and Flocculation Aids.....	HERBERT E. HUDSON JR.	242
Western Slope Water Development in Denver.....	EARL L. MOSLEY	251
Peak Demand Storage.....	SIMON W. FREESE	263
Effects of Sprinkling Restrictions.....	GLEN D. HEGGIE	267
Correction—Liquid Alum at Milwaukee (JAMES E. KERSLAKE).....		276
Water Supply From Upland Storage.....	LEON G. WILLIAMS	277
Reprints Available.....		282
Ground Water in the South Carolina Coastal Plain.....	GEORGE E. SIPLE	283
Automation and the Automatic Valve.....	WILLIAM F. END JR.	301
Treatment of Industrial Water Pollution at Nitro and Charleston, W.Va.	LAWSON HAYNES	309
Steel Pipe Joint Standards Revised.....		312
Water Supply for Large Industries.....	ROBERT C. LEWIS	313
Submerged Aquatic Plants in a Primary Settling Reservoir	WILLIAM BRIDGE COOKE, WILLIAM MARCUS INGRAM, ALFRED F. BARTSCH & J. DANIEL ENRIGHT	318
A Water Supply for Suburban Cincinnati.....	HAROLD H. MACE	322
Value of Sludge Calcining.....	FRED KRAUSE	327
Report of the Committee on Water Works Administration.....		331
AWWA Safety Awards Plan.....		339
Report of the Committee on Water Works Practice.....		341
Report on Publications.....		349
Report of the Audit of Association Funds.....		361
Section Membership Awards and Statistics.....		367

April

Estimated Use of Water in the United States.....	KENNETH A. MACKICHAN	369
Correction—Water Works Practice Committee Report.....		391
Pollution of Ground Water.....	WORLD HEALTH ORGANIZATION REPORT	392
Water Conservation Through Control of Evaporation	BUELL W. BEADLE & ROBERT R. CRUSE	397
Warm-Water Effects on Municipal Supplies.....	CHARLES E. RENN	405
Some Details of Water Treatment Plant Design.....	CLYDE R. HARVILL	413
Study of Permanent Color Comparator Kits for Fluorides.....	TASK GROUP REPORT	417
Plastic Pipe in Water Supply Use		
Installation Methods in Los Angeles.....	MAX K. SOCHA	427
Domestic Water System Uses.....	JOHN N. SPAULDING	433
Progress in Plastics.....	HAROLD H. YACKEY	434
Correction—Diatomite Filters for Municipal Installations (E. ROBERT BAUMANN)....		438
Design and Rating of Wells and Well Fields.....	LYNN M. MILLER	439
Reprints Available.....		449
Precast Concrete Rapid Sand Filter Underdrain.....	KENNETH W. COSENS	450
Correction—South Carolina Ground Water (GEORGE E. SIPLE).....		456
Recording Bacteriological Data.....	E. JOE MIDDLEBROOKS & GRAHAM WALTON	457
Use of Activated Silica in Water for Textile Finishing.....	FREDERIC A. PRISLEY	459

Characteristics of Limestone and Dolomite Aquifers in Western Ohio	STANLEY E. NORRIS	464
Engineers in Short Supply	NATHANIEL J. KENDALL	469
Municipal Water Supplies in New Mexico	CLYDE S. CONOVER	475
Anionic Synthetic Detergents and Water Supply Problems	CLAIR N. SAWYER & DEVERE W. RYCKMAN	480
Underground Pumping Stations	DEAN S. KINGMAN	491
Distribution Controls at Madison, Wis.	ELMER L. NORDNESS	499

May

Disposal of Radioactive Wastes	ABEL WOLMAN	505
Uniformity of Fluoride Ion Concentration in Newburgh, N.Y., Distribution System	FLOYD B. TAYLOR	512
Pipeline Network Analysis by Electronic Digital Computer	LYLE N. HOAG & GERALD WEINBERG	517
Meeting Increasing Demands in San Diego County, Calif.	PAUL BEERMANN & RICHARD S. HOLMGREN	525
Growth and Conversion of Water Systems in San Diego County, Calif.	LINDEN R. BURZELL	531
Growing Use of Water for Irrigation in Illinois	R. D. BLACK	537
Review of Experiences with Microstrainer Installations	GEORGE R. EVANS	541
Discussion	E. WINDLE TAYLOR	549
A Survey of Operating Data for Water Works in 1955	STAFF REPORT	553

June

Impact of Water Use for Air Conditioning on Chicago's Water System	HYMAN H. GERSTEIN	697
High-Demand Restriction at Kansas City, Mo.	MELVIN P. HATCHER	705
National and Local Aspects of Water Resources Problems	HENRY B. HOLMES JR.	712
Water Law in Eastern United States		
North Carolina and Other Atlantic States	CLAUDE L. LOVE	721
Maryland	JOSEPH T. SINGEWALD JR.	728
Delaware	JOHN J. GROOT	731
Iowa	WENDELL PENDLETON	733
Correction—South Carolina Ground Water (GEORGE E. SIPLE)		742
Radioactive Tracers in Sanitary Engineering	CONRAD P. STRAUB & G. RICHARD HAGEE	743
Stream Surveys for Radioactive Waste Control	ERNEST C. TSIYOGLU, ERNEST D. HARWARD & W. MARCUS INGRAM	750
Radiochemical Procedures for the Identification of the More Hazardous Nuclides	BERND KAHN & ABRAHAM S. GOLDIN	767
Butterfly Valve Design and Application	HENRY C. SCHWENK	772
Automation in Recent Water Purification Plants	ELLWOOD H. ALDRICH	775
Procedure and Interpretation of Fire Flow Tests	GEORGE TATNALL	779
Investigation and Handling of Water Quality Complaints	WILLIAM M. WALLACE & ALBERT M. SHANNON	785
Reprints Available		790
Construction and Public Relations	GERALD W. JONES	791
Automatic Chlorination Control by Continuous Remote Residual Determination	WILLIAM BRUCE MURRAY	795
Glassy Phosphates in Water Treatment	GEORGE L. ILLIG JR.	805
Maintenance of Rock Wells	CLAUDE R. ERICKSON & RALPH C. WRIGHT	817
Correction—Activated Silica in Water for Textile Finishing (FREDERIC A. PRISLEY)		824

July

Basic Principles of a National Water Resources Policy	
Preamble.....	ABEL WOLMAN 825
AWWA Statement of Policy.....	COMMITTEE REPORT 831
Municipal Utilities and the Fringe Area.....	GEORGE H. ESSER JR. 834
Use of Monomolecular Layers for Reservoir Evaporation Reduction	
LLOYD O. TIMBLIN JR., W. T. MORAN & W. U. GARSTKA	841
Biological Oxidation of Hexadecanol Under Laboratory Conditions	
F. J. LUDZACK & M. B. ETTINGER	849
Financing Water Works Improvements in Michigan— <i>Panel Discussion</i>	
DONALD C. EGBERT, JOHN D. HARRISON, JOHN E. VOGT & STRATTON S. BROWN	859
Applications of Submersible Pumps.....	JAMES E. BARRY 870
The Determination of Free and Combined Chlorine in Water by the Use of Diethyl- <i>p</i> -phenylene Diamine.....	ARTHUR T. PALIN 873
Stray-Current Corrosion of Underground Distribution Systems.....	DONALD W. BARRON 881
Duties and Qualifications of Operators of Small Water Works...WALTER F. ROWLAND	887
Certification of Water Works Operators in Illinois.....WILLIAM J. DOWNER	890
Developments in Well Production and Maintenance	
Madison, Wis.	ELMER L. NORDNESS 897
Illinois.....	HARMON F. SMITH & ROBERT T. SASMAN 903
Kalamazoo, Mich.	PAUL SABO 905
Reprints Available.....	909
Construction Equipment for Small Water Utilities.....WILLIAM K. FOERSTER	910
Installation and Maintenance of Valves and Hydrants at Wilmette, Ill.	
LEONARD F. LINDEEN	913
Rate Making for Small Water Works.....ALBERT P. LEARNED	923
Water Quality Problems in Small Water Works Systems.....CARL B. JOHNSTON	929
Recommended Meter Testing Procedure Available.....	936
Organizing a Safety Program.....MARK B. WHITAKER	937
1956 Safety Record at Chicago.....	940
Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe.....AWWA C203-57	941

August

New Jersey Water Supply Development— <i>Panel Discussion</i>	
ROBERT B. MEYNER, WILLIAM H. BAUMER & CHARLES H. CAPEN	969
Review of Oregon Water Law.....FRED MERRYFIELD	986
Nomenclature of AWWA Standards.....	992
Need for Planning in Utilizing Water Resources.....M. J. SHELTON	993
Water Works Planning in Great Britain.....GEOFFREY M. BINNIE	1001
Discussion.....	HARRY E. JORDAN 1005
Developments in Saline Water Conversion.....DAVID S. JENKINS	1007
Discussion.....	SHEPPARD T. POWELL 1018
Off-the-Job Safety Programs.....GEORGE C. SOPP	1020
Court Opinions on Pipeline Breaks.....JOHN H. MURDOCH JR.	1025
Cleaning and Relining Small Mains	
Reconditioning Water Mains at Cleveland.....FRANK J. SCHWEMLER	1029
Cleaning and Relining at Norfolk.....ROBERT W. FITZGERALD	1037
Installing Cement Linings at Rochester.....LEWIS B. SMITH	1039
Application of Electronics to the Water Supply Industry.....HOWARD JACOBY	1043
Discussion.....	SAMUEL A. SCHARFF 1049
Reprints Available.....	1052
Urban Water Requirements in California.....MAX BOOKMAN	1053

How Probable Is the Most Probable Number?.....	RICHARD L. WOODWARD	1060
Use of Radioactive Culture Media		
GILBERT V. LEVIN, VENTON R. HARRISON & WALTER C. HESS		1069
Safe Use of Truck-mounted Power Winches.....		1076
Proposed Standard Methods for Methane Determination.....	COMMITTEE REPORT	1077
Mixed Bed Ion Exchange for the Removal of Radioactivity.....	H. GLADYS SWOPE	1085
Advantages of Monthly Billing for Water Utilities.....	A. VINCENT AGNEW	1103
Discussion.....	HARRY E. JORDAN	1106

September

Present Bond Market Status.....	GEORGE I. MCKELVEY JR.	1107
An Evaluation of Water Utility Earnings		
Introduction.....	LOUIS R. HOWSON	1112
Michigan.....	CLAUD R. ERICKSON	1113
Dallas.....	HENRY J. GRAESER	1115
Los Angeles.....	BURTON S. GRANT	1126
Danville, Va.	EDGAR M. HAWKINS JR.	1130
Adequacy of Earnings.....	M. H. MCGUIRE & FRED MERRYFIELD	1133
Knoxville.....	MARK B. WHITAKER	1135
Development of a Rural Public Water Supply		
Limited Service to Partially Developed Areas.....	J. MORAN ROBERTS	1139
Gainesville, Ga., Experience.....	T. RILEY MILAM	1145
Land Policy for Impounding Reservoirs.....	FRANCIS S. FRIEL	1147
Discussion.....	E. SHERMAN CHASE	1156
Discussion.....	HENRY J. GRAESER	1158
Public Access to Lands Surrounding Impounding Reservoirs		
Recreational Use in Indianapolis.....	DANIEL P. MORSE	1160
Seattle Watershed Access Policy.....	E. JERRY ALLEN	1169
East Bay District Policy.....	JOHN W. MCFARLAND	1172
Correction—Biological Oxidation of Hexadecanol Under Laboratory Conditions		
(F. J. LUDZACK & M. B. ETTINGER)		1178
Experimental Evaluation of "Water Conditioner" Performance		
ROLF ELIASSEN & ROLF T. SKRINDE		1179
Factors to Be Considered in House Piping Sizes and Selection of Meters		
C. M. MATHEWS		1191
Repairing a Water Main From the Inside....	MAURICE BRUNSTEIN & JAMES S. LONG	1195
Maintaining Pipeline Flow Capacity After Cleaning		
WILLIAM D. MONIE & HAROLD B. SCALES		1200
Reprints Available.....		1212
Mineral Quality of Illinois Rivers.....	THURSTON E. LARSON & BERNT O. LARSON	1213
Oxidation-Reduction Potential Measurements Applied to Iron Removal		
JAMES G. WEART & GERALD E. MARGRAVE		1223
Climate, Fluid Intake, and Fluoridation.....		1233
New Method for Fluoride Determination		
FLOYD I. BROWNLEY JR. & EDGAR E. SELLERS		1234

October

Experience in Applying Fluorides—Panel Discussion

JOHN R. BAYLIS, JOHN C. SMITH, JOHN W. KRASAUSKAS, H. CHRISTOPHER MEDBERY, JEROME C. ZUFELT, ALBION A. BAILEY, ELWOOD L. BEAN, JAMES E. KERSLAKE, BENJAMIN C. NESIN, A. P. BLACK, MARSHALL P. CRABILL, ATTMORE E. GRIFFIN & ROBERT S. PHILLIPS		1239
--	--	------

Revised Cast-Iron Pipe Manual Available.....	1278
Problems in Personnel Recruiting.....	MILTON ROSEN 1279
Recruiting and Training of Personnel.....	W. A. HARDENBERGH 1283
In-Service Training and Certification.....	RAYMOND J. FAUST 1288
Corrosion and Tuberculation of Cast Iron.....	THURSTON E. LARSON & R. V. SKOLD 1294
Protective Coatings for Water Distribution Systems.....	ROBERT F. McCAULEY 1303
Studies of Cadmium and Chromium Solubility and Toxicity.....	ROBERT D. MACKENZIE, C. A. HOPPERT & R. U. BYERRUM 1310
Correction—Plastic Pipe—Installation Methods (MAX K. SOCHA).....	1312
Survival of Elevated Storage Tank in Suburban Kansas City Tornado..	STAFF REPORT 1313
Techniques in the Use of Liquid Alum— <i>Panel Discussion</i>	
	NORMAN E. JACKSON, RICHARD W. OCKERSHAUSEN, DAVID LURIE, JAMES E. KERSLAKE & OSCAR GULLANS 1315
Underground Waste Disposal and Control.....	TASK GROUP REPORT 1334
Carbonation of Water Softening Plant Sludge.....	F. A. EIDSNESS & A. P. BLACK 1343
Discussion.....	FREDERICK G. NELSON 1351
Effects of Synthetic Detergents on Water Supplies.....	TASK GROUP REPORT 1355
Reprints Available.....	1358
Factors Affecting Long-Distance Transmission of Water.....	LOUIS R. HOWSON 1359
Wisconsin's Policy on Municipal Utility Taxation.....	ARTHUR P. KURANZ 1369

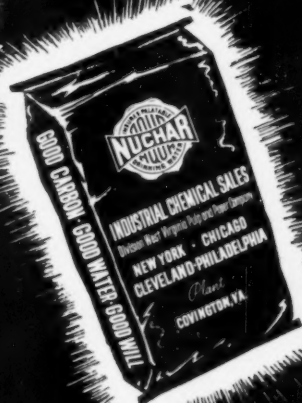
November

Telemetry and Remote Control by the Long Island Water Corporation.....	SAMUEL C. McLENDON & MICHAEL ZIHAL 1371
Automation and Remote Control of Chemical Feeders.....	PAUL A. COFFMAN JR. 1378
Electrical Supervisory Controls at Vancouver, Wash.	MARVIN H. SCHROEDER 1387
Future Developments in the Greater Winnipeg Water District....	NATHAN S. BUBBIS 1389
Honolulu Water Supply.....	EDWARD J. MORGAN 1403
Review of the Jar Test.....	A. P. BLACK, ARTHUR M. BUSWELL, FRED A. EIDSNESS & A. L. BLACK 1414
Improved Jar Test Procedure.....	JESSE M. COHEN 1425
Influence of Bicarbonate Ion on Inhibition of Corrosion by Sodium Silicate in a Zinc-Iron System.....	HENRY L. SHULDENER & LEO LEHRMAN 1432
Further Study of Solution Effects on Concrete and Cement in Pipe.....	MARTIN E. FLENTJE & ROBERT J. SWEITZER 1441
Correction—Urban Water Requirements in California (MAX BOOKMAN).....	1451
Comparison of Standard Dilution and Membrane Filter Methods..	REGINALD B. ADAMS 1452
Recent Meter-setting Developments.....	
Introduction.....	W. VICTOR WEIR 1459
Indoor or Outdoor Installation?.....	JAMES G. CARNS JR. 1460
Philadelphia.....	GERALD E. ARNOLD 1465
Richmond, Va.	MARSDEN C. SMITH 1469
Ottawa.....	W. ELWOOD MACDONALD 1473
Correction—Experimental Evaluation of "Water Conditioner" Performance (R. ELIASSEN & R. T. SKRINDE).....	1477
Status of Fluoridation in the United States and Canada, 1956....	TASK GROUP REPORT 1478
Direct Spectrophotometric Determination of Chloride Ion in Water.....	PHILIP W. WEST & HANS COLL 1485
Strontium Content of Wisconsin Municipal Waters.....	M. STARR NICHOLS & DOROTHY R. McNALL 1493
Reprints Available.....	1498
Design of Underground Storage Reservoirs.....	ALLAN B. PATTERSON 1499

December

Control of Odor and Taste in Water Supplies.....	E. A. SIGWORTH	1507
Progress Toward AWWA Certification Program.....		1521
Survey of Water Purification Practice in Canada		
	DELOSS H. MATHESON & A. V. FORDE	1522
Acceptability of Membrane Filter Procedure.....		1530
A Statistical Analysis of Water Works Data for 1955		
	HARRIS F. SEIDEL & E. ROBERT BAUMANN	1531
Summary of 1955 USPHS Survey of Treatment Facilities in Communities of 25,000 and Over.....	RALPH PORGES	1567
Correction—1955 Operating Data Survey.....		1580
Evaluation of the Use of Polyphosphates in the Water Industry...THURSTON E. LARSON		1581
Revenue-producing Versus Unaccounted-for Water.....COMMITTEE REPORT		1587
Factors Limiting Financing of New Water Works Construction...ALFRED LEFEBER		1593
1957 Conference—Atlantic City.....		1595
Papers Scheduled at 1957 Section Meetings.....		1605
Reprints Available		1616
Index for Volume 49, 1957		
Subject Index		1619
Author Index.....		1631
Binding the Year's Journals.....		1638

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American and Canadian Cities.



Percolation and Runoff

P&R is 10 years old! So, too, of course, not are, but is Editors Anonymous—the disorganization of unidentified contributors of material herein converted into the language of “the 10-year-old.” And if P&R’s anniversary* is more to be observed than celebrated, let it not be so with Editors Anonymous’s, for to be an EA is to be unobserved. In celebration, then, of the first full decade of Editorial Anonymity, we (the strictly editorial “we,” at least) who profit by EAism wish to salute all 145 anonyms, living and dead, who have provided the wherewithal for P&Rticles past and present. Over the years we have taken advantage of this season of peace and goodwill to risk disanonymizing the currently active members of this super-secret sort of society, the better to thank them for their contributions. And with this tenth Christmas upon us, we venture once more to unhear our Santa Cli and to note not only the extent of their present responsibility for P&R, but the number of years during which they have incognitoed our lines.

With the completion of a full decade of Editors Anonymous, it has been

* The picture of Willing Water carrying the anniversary torches is provided by courtesy of the Maritime Branch of AWWA’s Canadian Section, which had the cake baked to celebrate its own tenth meeting and then borrowed unbeknownst.



necessary to establish a new classification of membership—*Fully Decadent*—to do justice to three whose *Incurability* has been manifest from the very beginning of P&R. Meanwhile, it will be well to point out again that those listed below as *Incurables* can’t help but help us; the *Deetees* frequently have; the *Shakes*, occasionally; and the *Jitters*, once or twice, whether they have known it or not. The powers ascribed to them, of course, are the measure of their years of helpfulness:

Fully Decadent

E. L. Filby¹⁰ J. M. Wafer¹⁰
P. S. Wilson¹⁰

Incurables

C. H. Capen⁹ M. D. Saunders¹
D. C. Colebaugh⁸ E. A. Sigworth⁸
M. J. Harper⁵ H. J. Spaeder²
W. R. LaDuc⁷ R. L. Tyler⁶
C. E. Painter⁵ Henry Wilkens³

Deetees

N. M. DeJarnette⁶ Fred Merryfield⁸
D. N. Fischel⁹ A. S. Metcalf¹
R. E. Hansen⁶ D. B. Williams⁶

Shakes

H. A. Faber⁸ A. E. Griffin²
M. E. Flentje⁶ G. E. Symons⁸

(Continued on page 42 P&R)

(Continued from page 41 P&R)

Jitters

H. W. Badley ¹	John Kleinhenz ⁴
Don Berkow ¹	G. J. Manahan ²
A. P. Black ⁶	Jack McKee ¹
M. T. Bramman ²	Mildred Merryfield ¹
J. W. Cramer ¹	L. S. Morgan ²
J. W. Finney ¹	X. D. Murden ²
D. J. Ford ¹	H. J. Ongerth ²
J. L. Ford ¹	B. E. Payne ⁵
Philip Grannan ²	H. G. Reichardt ²
L. W. Helmreich ¹	J. S. Rosapepe ⁴
W. T. Ingram ²	G. R. Scott ²
R. L. Jones ²	Brian Shera ²

W. A. Welch⁴

To all the helpful—the 48 of '57 and the almost 100 others since '48, not to mention the readers of P&R, severally—*Merry Christmas!* And not only to them, but to ourself via their continued helpfulness, *Happy New Year!*

Speaking of P&R reminds us of the notice in the February issue of the *Consulting Engineer* concerning the development at the USSR Academy of Sciences of an electronic computer that automatically translates texts from English into Russian. Knowing that a considerable number of copies of the JOURNAL go to Russia—and even to the Academy where the robot is located—we can't help but wonder what would come out if one of the more abstruse P&Rticles were fed into the translator—or was that what happened to Zhukov?

AWWA's certification program is still a-borning, primarily because its birth is being attended by many more pangs—legal and administrative—than were premeditated at its conception. The obstetrical target is now the last week in January 1958, when the Board of Directors will give its attention to slapping some life into the recommendations delivered by its General Policy Committee. In the meantime, to make

certain that the new baby has the very best chance not only of survival, but success, its parents and godparents are busy working out solutions to the problems that will face it. Comes January, comes cigars, we hope, but right now AWWA paces uncertified.



T. T. Quigley



R. C. Clement

Wallace & Tiernan Inc. has announced the promotion of personnel in its equipment divisions, effective Jan. 1, 1958. Thomas T. Quigley is to be director of equipment divisions; Russell C. Clement, director of sales for chlorination and chemical-feeding equipment; and Donald N. Hale, production manager. Mr. Quigley joined the firm in 1940 and has served most recently as executive assistant to the vice-president. Mr. Clement, with the company since 1924, was manager of field sales and service. Mr. Hale has been with Wallace & Tiernan since 1936, and has had experience in sales, sales engineering, and production.

A. R. Fisher has been named chairman of the board of Johns-Manville Corp., succeeding Leslie M. Cassidy, who retired. Mr. Fisher continues as president and director, offices which he has held since 1951. Clinton B. Burnett has been elected executive vice-president.

(Continued on page 44 P&R)

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filter gauges and controllers
give you 3 important advantages

1. *Positive Controlled Air Pressure*
2. *Instant, accurate measurements of head and flow ... plus automatic flow control*
3. *Elimination of troublesome cables, piping, stuffing boxes or accessories*

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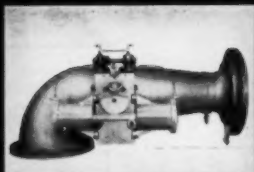
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C.-A.-P. SYSTEM[®] Instruments



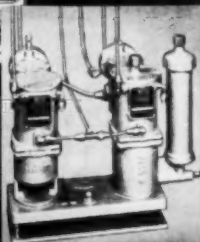
Rate of flow controller is accurate and dependable.



Loss of head and rate of flow indicator and recorder is simple and easy to read



Converters may be mounted in convenient location



Typical operating console is compact and accessible

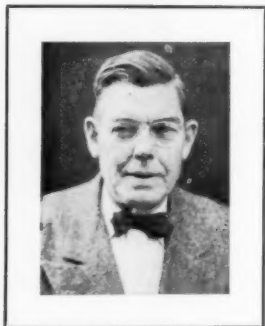


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(Continued from page 42 P&R)



Linn H. Enslow, editor of *Water & Sewage Works* magazine, New York, died at his farm in Dublin, Va., Nov. 3, 1957. He was 66. Born at Richmond, Va., in 1891, he received a BS in chemistry from Virginia Polytechnic Institute in 1912 and became assistant works chemist with General Chemical Co., Baltimore, Md., the same year. In 1913 he engaged in postgraduate studies in chemistry and electrical engineering at Johns Hopkins and the following year undertook part-time work with the Maryland Health Dept. In 1915 he became assistant chemist on a full-time basis with the department, and 2 years later was placed in charge of the water and sewage laboratory.

During his service with the department he was associated with Abel Wolman in an intensive study of the application of chlorine to the water supplies of Maryland. From this study it was learned that the observed chlorine residual in treated water could be relied on as an indicator of the efficiency of the process. Actually, this study has become the foundation on which modern water chlorination is grounded.

In 1918 he became chemist in charge of the Spartanburg, S.C., filtration

plant and the next year accepted a post as chemist at the Panama Canal, where he also supervised the filter plant. He returned to Virginia in 1920 to become assistant engineer with the State Health Dept., leaving after 5 years to take a position as research engineer with The Chlorine Institute, New York. In 1931 he was named editor of *Water & Sewage Works*.

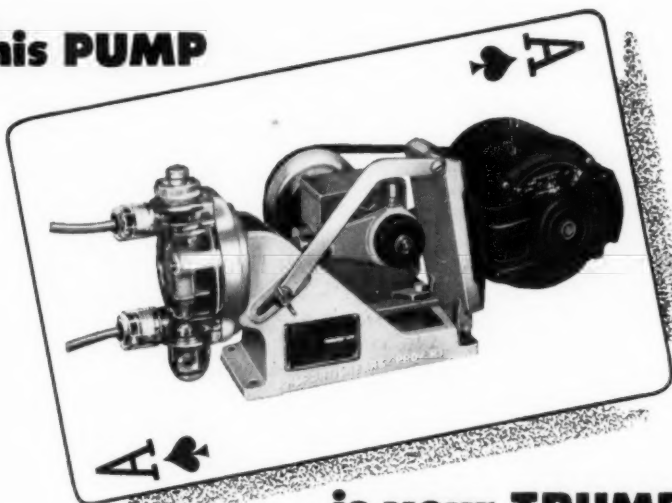
An Honorary Member of AWWA (joined in 1918), he served as director and president, and was chairman of the Publication Committee for many years. In recognition of his services to AWWA and the public water supply field, he was presented with the Diven Medal in 1935, the Goodell Prize in 1950, and the Fuller Award in 1951. He also belonged to AIChE, APHA (fellow), ASCE, British Institute of Sewage Purification (honorary member), FSIWA (vice-president), NEWWA, and a number of local water and sewage works associations, and was a past-chairman of the WSWMA Executive Committee.

Mr. Enslow possessed an inquiring and analytical mind, a quality manifested throughout his life. Those present at the meeting of the Chesapeake Section of AWWA, which he attended less than a week before his death, will recall that he participated in the technical discussions in his characteristically constructive fashion. In the course of his career, he added greatly to the professional advancement of the water industry.

Reginald M. Atwater, executive secretary of the American Public Health Assn., died Oct. 18, 1957, at the age of 65. Born at Canyon City, Colo., in 1892, he was graduated from Colorado College in 1914 and received

(Continued on page 46 P&R)

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is your TRUMP...

STERILIZE your own water supplies!

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B-I-F INDUSTRIES



METERS
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CONTROLS

(Continued from page 44 P&R)

an MD from Harvard in 1918. After completing his internship, he obtained a doctorate in public health from Johns Hopkins in 1921. In 1927, following a period of teaching at Hunan Yale College in China and Harvard, he became health commissioner for Cattaraugus County, N.Y., a post he held until 1935, when he was named executive secretary of APHA. He was managing editor of the *American Journal of Public Health* and chairman of the APHA Program Committee, as well as a special consultant to the US Public Health Service and a board member of the National Health Council.

Arthur C. Ford has been named to the New York City Board of Water Supply, succeeding the late Irving V. A. Huie as president. Armand D'Angelo becomes the new commissioner of the city's Dept. of Water Supply, Gas & Electricity, a post occupied by Mr. Ford since 1954. Mr. D'Angelo, an official of an International Brotherhood of Electrical Workers local, has been deputy commissioner since 1955.

The 'when' and 'where' of our favorite slogan—"All the Water You Need, When and Where You Need It!"—seem to be the major difficulties as far as the overall problem of water resources is concerned. At any rate, with our present total use estimated to be no more than 5-15 per cent of the total amount of precipitation available after transpiration and evaporation losses, it would seem that, even without going to the seas around us, we can obtain all the water we need, and then some.

The "when" problem, of course, is a matter of timing, not only of rainfall, but of water storage facilities. Thus, though an "unusually" dry year was the primary cause of the shortage in

New York City in 1949-50, an important part of the "when" of it was the fact that the war had delayed completion of the Delaware River supply, which was able to carry the city through a drier period without trouble this year. Similarly, New Jersey's problem is more "when" than anything else—"when," that is, it will decide to make fuller use of the resources which are available. Actually, all through the 31 eastern states, where the average net precipitation available is estimated at 16 in., the problem is generally a "when" one, based on when communities or states or regions decide that the water available is worth the price of its development.

The "where" problem, on the other hand, is one characteristic of areas that basically do not have enough water available to support the type of economy desired. Southern California is a "where" area, in which the problem has been one of going long distances to import water and, thus, facing difficulties not only in financing the facilities required, but in obtaining rights to the water involved. On the basis of the estimate that a net of less than 1 in. of water per year is available to our western states, it is not difficult to see why the accent must be on "where."

One new "where" for the West these days has been in evaporation control, to make more of the rainfall available—and research, particularly on the use of hexadecanol in a monomolecular film to hold stored water, has been most promising. Similarly, research on various methods of desalting sea water and brackish water has been progressing, the only problem now being one of doing the job at a price the customer is willing to pay. Meanwhile, someone has finally picked a "where" even beyond our reach in suggesting a

(Continued on page 48 P&R)

SURGEABILITY

THE LATEST WORD IN WATER TREATMENT

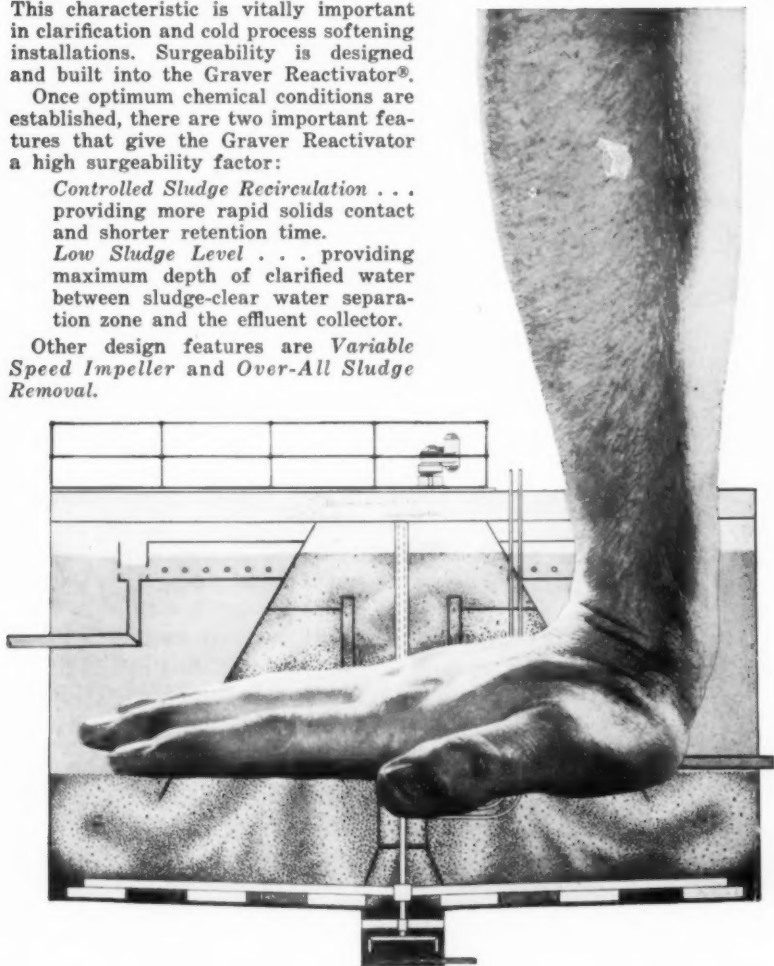
Surgeability is defined as stability of performance under rapidly changing and unpredictable conditions including flow. This characteristic is vitally important in clarification and cold process softening installations. Surgeability is designed and built into the Graver Reactivator®.

Once optimum chemical conditions are established, there are two important features that give the Graver Reactivator a high surgeability factor:

Controlled Sludge Recirculation . . . providing more rapid solids contact and shorter retention time.

Low Sludge Level . . . providing maximum depth of clarified water between sludge-clear water separation zone and the effluent collector.

Other design features are *Variable Speed Impeller* and *Over-All Sludge Removal*.



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Anticipate Surge

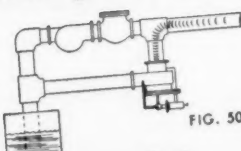


FIG. 500-A

with the **G-A**
ANTI-SURGE VALVE
Bulletin W-16

Relieve Surge

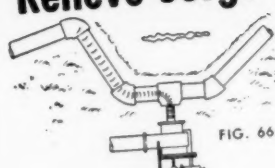


FIG. 66-D

with the **G-A**
SURGE RELIEF VALVE
Bulletin W-2

Prevent Surge

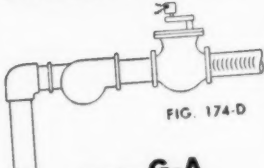


FIG. 174-D

with the **G-A**
ELECTRIC CHECK VALVE
Bulletin W-10

WRITE

GOLDEN
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Valve Specialty Company

1221 RIDGE AVE. • PITTSBURGH 33, PA.

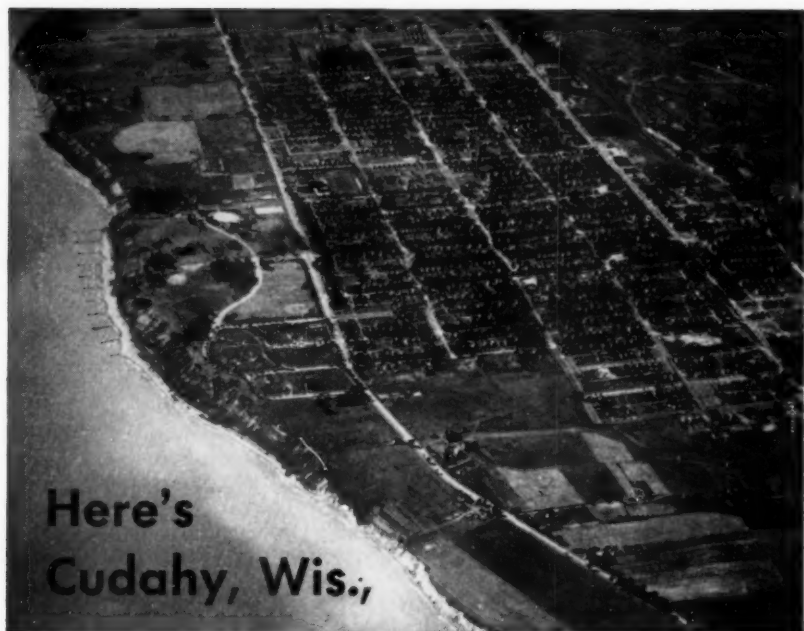
Designers and Manufacturers of

VALVES FOR AUTOMATION*(Continued from page 46 P&R)*

method of obtaining fresh water which we still consider our idea—that is, tapping icebergs. The latest version of this technique was reported recently as being “seriously considered by experts.” Thus, according to John D. Isaacs of the Scripps Institute of Oceanography, “it would be possible for tugboats in Antarctic waters to guide icebergs to such water-short cities as Los Angeles.” The idea is that the tugs would pick up one of the bergs that floated thousands of miles north on the Humboldt current and nudge it the rest of the way up to Los Angeles. Once the berg was in position, a watertight fence would be built around it and the ocean water would be pumped out. The berg, in melting, would form a fresh water lake that could supply the city for a full year.

With more fresh water in the polar ice caps than in all other sources combined; with Kuwait on the Persian Gulf and Curacao in the Dutch West Indies already using the sea as a source of fresh water; with eight countries backing a Dutch project to develop the Sahara and to supply farms in South Africa and Australia with water desalted electrically at costs of \$1.20 per cubic meter (264.2 gal) from the sea and 39 cents per cubic meter from brackish sources; with Saudi Arabia already going ahead with plans to pipe water some 450 miles across the desert from the river Euphrates in Iraq to its 200,000-population capital city, Riyadh; and with even the Virgin Islands importing water via tugboat from Puerto Rico, who will say that it is impossible, or even impractical, for water utilities to work toward providing their customers “all the water they need, when and where they need it,” provided, of course . . . ?

(Continued on page 50 P&R)



**Here's
Cudahy, Wis.,**

where ALOXITE underdrains mean economical filtration

When Cudahy put up its modern plant an important decision was made which assured both initial and long-term economy. It was this: Instead of graded gravel filter beds, Cudahy chose to support its sand filters with ALOXITE® aluminum oxide porous plates.

ALOXITE plates eliminated the need and cost of graded gravel and other types of underdrainage systems. And, most important, they virtually eliminated the need for filter repairs, so that the savings will increase year after year. Like all ALOXITE plate underdrains they can handle growing loads with freedom from mudballs and with minimum loss of head. And complete backwashing is accomplished without upset beds.

Construction of the new filtration plant at Cudahy was under the supervision of James Tiry, Director of Public Works and John Martinek, Water Superintendent. Answer your questions about porous media by writing for informative 56-page booklet. It's yours for the asking from:

CARBORUNDUM

Registered Trade Mark

Dept. O-127, Refractories Division, Perth Amboy, N. J.

(Continued from page 48 P&R)

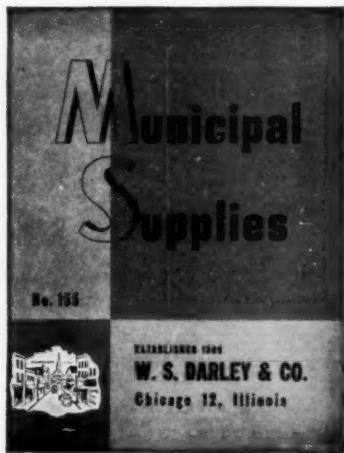
Poor fish is right! In the Great Lakes, the lampreys have been destroying them in such numbers that the US Fish and Wildlife Service has had to set up electrically charged lines to repel the lampreys from entering feeder streams in which they spawn or, if they have spawned, to prevent their return to the lake. At Reading, Pa., a chemical applied to remove algae scum from Carsonia Lake, used chiefly for boating and fishing, did a beautiful job on the algae, but also killed at least 10,000 fish that suffocated from lack of oxygen. And at the public water supply reservoir at Orange, N.J., there was not enough water left last month to keep a fish alive, so that men from the state fish hatchery had to remove them. Compared with a fish's, a dog's life is out of this world!

An R for the water supply industry if not for the customer was filled by a New York drugstore the other day. In the language of the *New Yorker* magazine, it went:

Friend of ours became convinced that inflation is really upon us when he stepped up to a soda fountain in a drugstore near the Coliseum the other afternoon and asked for a glass of water to wash down a pill. Along with the water, he was handed a check for ten cents. As he proffered the check and a dime to the cashier on his way out, he remarked that he thought he was paying a pretty stiff price for a glass of water. "Oh," said the cashier, "is this check just for plain water? Then we've made an error." Smiling apologetically, she reached into her cash drawer and handed him a nickel.

What price water? A nickel per tin, of course!

(Continued on page 54 P&R)



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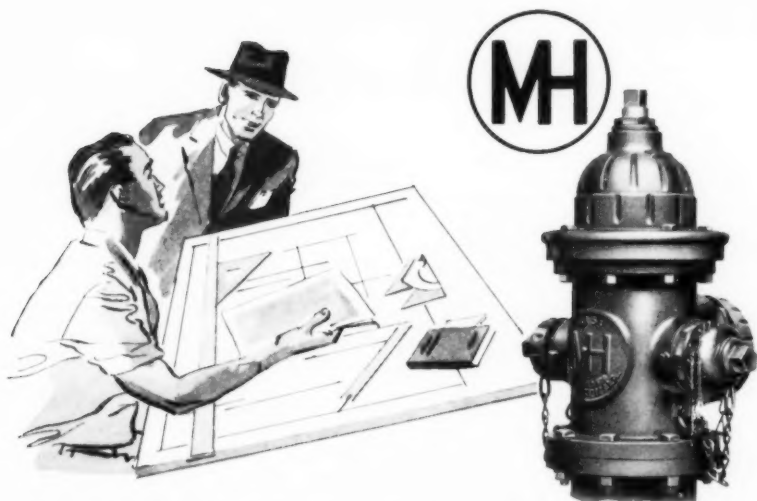
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M&H
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with
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Modern engineering and practical water works experience account to a great extent for the advantages and superiority of M & H valves and hydrants. In this respect, many M & H customers are unofficial members of our engineering staff. From their every-day operating experience, these men "on the firing line" have contributed greatly to the modern design of M&H products.

We have gratefully accepted their contributions, which we have tested through years of research in engineering, design and foundry practice. The result is that M & H valves and hydrants are now widely known for their easy, practical and dependable service year after year.

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Liquid Alum Means

SIMPLE AND

... and a 3-year pay-off

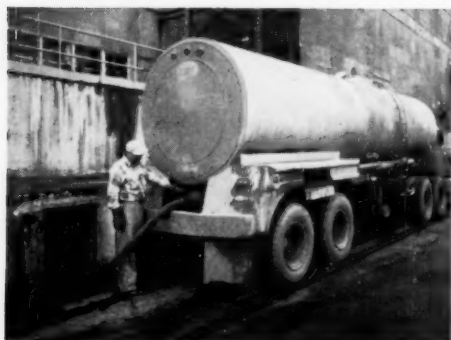
"We have been saving \$17,000 a year at the South District Filtration Plant since August 1954, when we replaced our dry-feed system with a liquid alum installation. The change-over cost, we estimate, is to be fully paid off in three years of operation.

"In addition to the monetary saving, we find the liquid alum system to be cleaner, simpler and certainly more dependable. There is no stratification of the liquid alum in storage or feed tanks, and easily controlled metering eliminates the overfeeding and underfeeding experienced with dry alum handling equipment.

"Our operating engineers and technical staff are well pleased with *all* aspects of the new system."

You may want to take advantage of the lower cost of liquid alum—or put your water treating on a cleaner, more efficient basis—or both. A Cyanamid representative can help you determine the annual savings in purchasing liquid alum. He can also advise you on the simple installation that will make your water-treating system cleaner and more efficient... capable of continual dependable performance with the minimum of supervision.

Benefit from Cyanamid's extensive experience in the conversion of dry-feed systems to liquid. Request a *Liquid Alum Survey*. Call or write your nearest Cyanamid Office.



"Liquid alum flows by gravity from rubber-lined tank trucks to our storage tanks. Our supervision is not required."



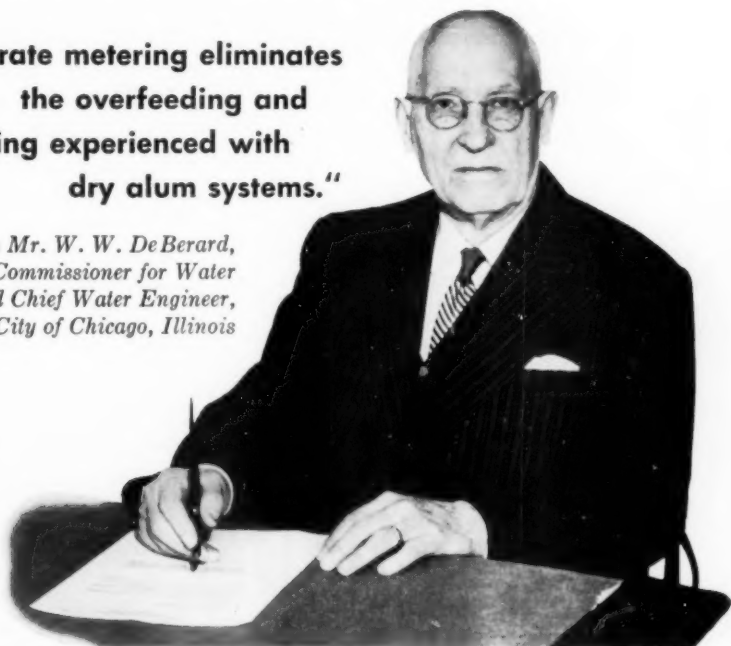
"The simplicity and neatness of our new liquid alum system (right) is evident by comparison with the old dry-feed system (left)."

DEPENDABLE OPERATION

on installation at Chicago

**"Accurate metering eliminates
the overfeeding and
underfeeding experienced with
dry alum systems."**

—says Mr. W. W. DeBerard,
Deputy Commissioner for Water
and Chief Water Engineer,
City of Chicago, Illinois



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needle valve and rotameter give accurate control
liquid alum feed, with a pengraph maintaining
rmanent record. Our old dilution system is used."



CYANAMID

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Toronto and Montreal

(Continued from page 50 P&R)

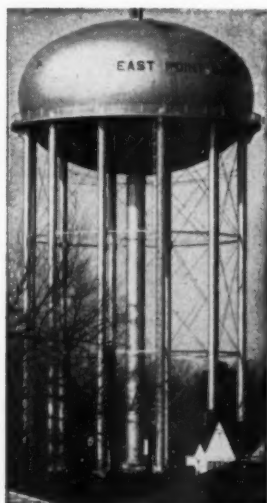
HOH for HRH on her recent visit to Canada and the United States was said to be 99.9 per cent "pure," having been drawn from Lake Ontario and "filtered through sand, activated carbon, and paper under the strict security of the Royal Canadian Mounties." All that purity-security business sounds just a bit strange to us in the absence of any disinfectant, but we suppose that depends upon where in Lake Ontario the Mounties dipped their bucket. We were surprised, too, and, as a matter of fact, happily so, to learn from the statement that "even the royal ice cubes were made from this water," that our British cousins have at last apparently come around to the appreciation of cold drinks—perhaps even Scotch on the rocks!

A 'U-Haul-It' water distribution system for slow-paying customers has been established by the Cheyenne, Okla., water department as a means of cutting down on the number of delinquent accounts. Now service is cut off promptly on the 15th of each month for customers who have not paid, but no one is forced to go without water. All the water a customer needs is provided free of charge, but not exactly where and when he needs it. It is made available at a hydrant in the city park on a come-and-get-it basis. Not perhaps the recommended technique in public relations, the system does, nevertheless, point up quite clearly what is being paid for. The slogan, no doubt, is: "Pay up or go to haul!"

ELEVATED WATER TANKS

Built in accordance with AWWA specifications, in all sizes and various types.

Send us your inquiry—stating capacity, height to bottom and location. Established 1854. Write for bulletins.



COLE Ovaloid Type

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**WITH CELITE DIATOMITE FILTRATION
YOU CAN GET CRYSTAL CLEAR WATER AND...**

WATERTOWN, U.S.A.

Why extreme purity is essential

3.45% Bonds

Sylvania uses every
the latest purity,
research and engineering
these impurities in her
production when it is
years of maintenance

So, when you need the
100% pure you
must make, you can
count on it when it is
used in Sylvania's semi-
conductor for most per-

formance. Germania
uses, you need Germania
with reliability of 30
electronic materials...
the components, world
crystal perfection.

M. Quaker
Water is the answer

Cut capital filtration costs as much as 45%

An actual installation by Johns-Manville established that a Celite® filter station can be constructed for 55% of the cost of a comparable sand filter plant.†

Diatomite systems not only cut costs, but, under comparable conditions, they also improve water clarity. For with Celite, turbidity is usually lower since more suspended impurities, including all floc, amoebae and algae, are removed. In fact in some cases, turbidity is so low it can't be measured.

Diatomite systems save space, too. To deliver the same installed capacity requires a sand filter plant 4 times as big.

Mined by Johns-Manville at the world's largest and purest commercial diatomite deposit, Celite is carefully processed for purity and uniformity. It is

available in a wide range of grades to deliver the best practical balance of clarity and flow rate with any suitable filter. For further information see your nearby Celite engineer or write for free technical reprints and illustrated brochure to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

Celite filter aids are composed of microscopic, irregularly-shaped particles like these. 90% of a given quantity of Celite is composed of countless channels and voids that trap the finest impurities while permitting the free passage of clear liquid.



†Celite is Johns-Manville's registered trade mark for its diatomaceous silica products. See *Comparison Studies of Diatomite and Sand Filtration* by G. R. Bell, Journal American Water Works Association, September, 1956, or write for free reprint.

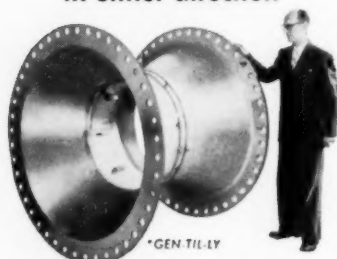


Johns-Manville CELITE Filter Aids



The *Gentile*
FLOW TUBE

measures flow
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Water Works School

To the Editor:

You may be interested in the water works school at San Luis Obispo, Calif., which, I think, is unique in that it is conducted under the auspices of the city school system. Membership in the class, however, is by no means limited to San Luis Obispo residents. In fact, some of the enrollees travel as much as 90 miles round trip to attend.

All but two of the 32 men in the last class have had from 5 to more than 15 years of actual experience in water and sewage plant operation (two members hold master's degrees), so that the total contribution to the welfare and improvement of the class is considerable.

The course was started in October 1956 in the San Luis Obispo Adult Evening School, Dr. O. B. Paulsen, principal, largely through the efforts of John Bader, of Oceano; Robert L. Byers, of Morro Bay; and Price Thompson, Carl Young, and Sam Schultz, of San Luis Obispo. Fairly close touch is maintained with the AWWA's California Section, on whose lecture outlines the curriculum is partly based. Specialists are frequently called on to talk on legal responsibilities, flow testing, and other topics of interest.

The enthusiasm of the group indicates that the school is performing a valuable service to the citizens in general and to the water works operators of this area in particular.

CHARLES O. BLODGETT

San Luis Obispo, Calif.
Sep. 11, 1957

Mr. Blodgett, the instructor for the course, has a BS in mathematics and chemistry, a master's degree in education with a minor in mathematics from Stanford, and a master's degree in cytogenetics with a minor in botany from the University of California; he has been teaching in high school and junior college for more than 20 years.—Ed.

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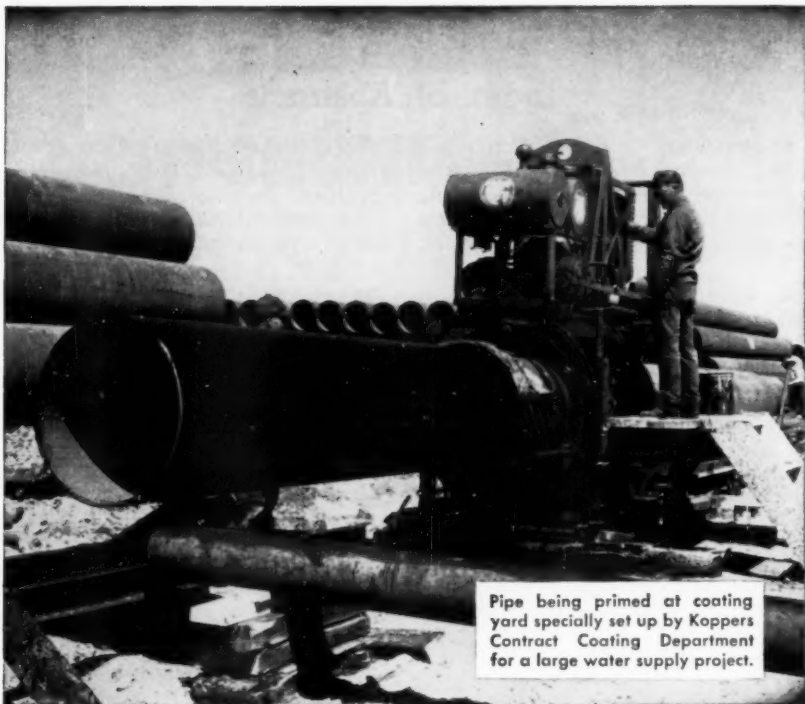
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Page numbers refer to P&R section of Journal. Letters immediately preceding page numbers refer to month of issue, using following key: Ja—January; F—February; Mr—March; Ap—April; My—May; Je—June; Jl—July; Au—August; S—September; Oc—October; N—November. All subjects and page numbers in boldface type indicate first pages of topic sections.

- Acid; dolomite for removal of, Ap 68
 Acid lactams; aminocarboxylic; influence of, F 66
 Actinomycetes; taste and odor due to, Ap 78, S 78
 Activated carbon; *see* Carbon
 Algae; blue-green; physiology and biochemistry of, S 86
 photosynthesis in, S 86
 problems in removal of, Ap 78, Je 81
 Alkaline materials; use of, in removal of silica, Ap 70
 Alkalinity; *see* Hardness; Ion exchangers; Softening and Iron Removal
 Aluminum; protection of, against corrosion, Oc 80
 Ammonium; phenolic; effects of, Jl 62
 quaternary; effects of, Jl 62
 Analysis; bacteriological; time factor in relation to, F 62
 hydrograph; methods of, Oc 92
 microvolume; method of, N 70
 volumetric; microchemical; limitations of, Oc 84
 Anthracite; filtration with, Ap 70
Aquatic Organisms, My 62, S 80
 effects of, on pollution, F 74
 Aquifers; *see* Ground Water
 Australia; dental observations on natives in, Au 72
 New South Wales; Newcastle; use of filters at, Jl 62
 Sydney; water supply of, Au 76
 Tasmania; Beaconsfield; fluoridation at, Ja 64
 Austria; mountain wells; fluctuating yield of, Au 86
 Salzburg; ground water resources of, Ja 70
 Vienna; disinfection problems of, Jl 62
 water supply in, N 74
 Bacteria; coliform; analysis of data on, F 68
 comparative examinations for detection of, F 66, F 68
 Bacteria (*contd.*); comparison of enterococci with, in wells, F 62
 EDTA as aid in maintaining index of, S 76
 modification of radiosensitivity of, by oxygen, S 74
 radiocarbon for detection of, S 77
 roll-bottle method for estimation of, S 78
 survival of, F 62, F 66
 temperature of culture media for, S 74
 use of geometric means in counts of, S 76
 removal of, with free chlorine, Jl 66
 review of dilution methods for estimation of, S 74
Salmonella; favorable environment for, S 77
 rapid method for identification of, S 76
Sphaerotilus natans; biology and metabolism of, S 77
Streptococcus faecalis; mannitol bile broth medium for, S 76
 thallium sulfate medium for, S 77
 sulfite reduction test for, S 77
 Bactericides; *see* Chlorination; Disinfection
Bacteriology, F 62, S 74
 Belgian Congo; Leopoldville; water supply of, Au 80
 water supply in, N 74
 Belgium; calcareous formations; water in, Je 81
 water supply in, N 74
 Benzenesulfonates; alkyl; determination of traces of, Oc 66
 spectrophotometric determination of, Oc 66
 Boiler water; phosphate in, Je 72
 problems with, in gas industry, Ap 66
 processes for treatment of, Je 66, Je 72
 resinous materials in, Je 68
 Boilers; *see also* Corrosion
 cleaning of, with molasses, Je 72
 prevention of scale in, Je 66
 seal coatings for, Je 72
 studies on corrosion of, Je 66, Oc 76

(Continued on page 70 P&R)



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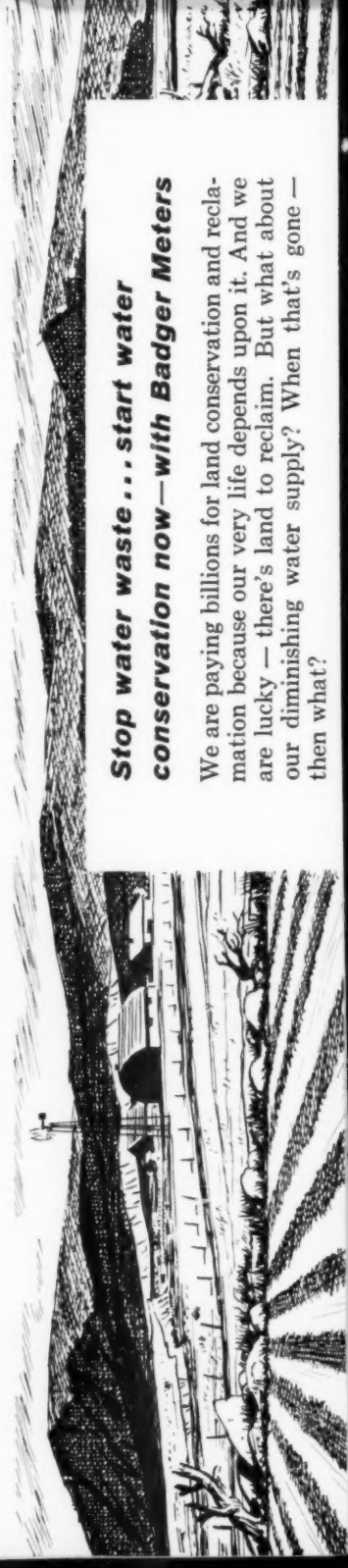
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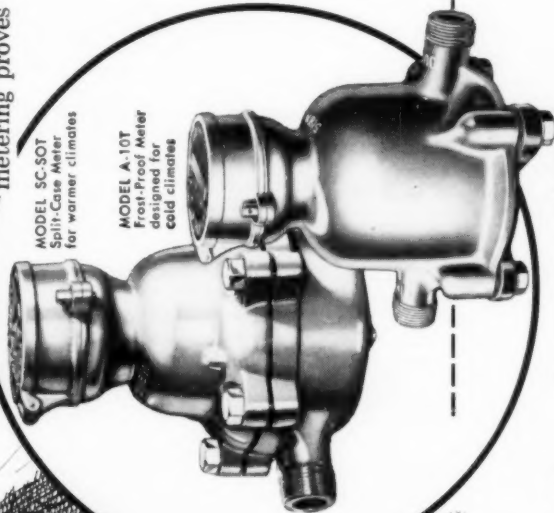
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(Continued from page 66 P&R)

Boilers and Feedwater, Je 66

Boiling; use of, compared with disinfection and filtration, J1 80

Calcareous formations; waters of, in Belgium, Je 81

Calcium; *see also* Hardness

complexometric determination of, Oc 70

determination of, in presence of magnesium, My 74

in rain water, Oc 70

EDTA for determination of, My 74

microchemical determination of, Oc 66

Calcium carbonate; formation of, Oc 90

Calculation equipment; use of, for distribution systems, Ap 76

California; San Diego; construction methods of aqueduct for, Mr 64

San Joaquin County; ground water resources of, Ja 72

Canada; *see also* entries under specific provinces

status of fluoridation in, Au 74

Carbon; activated; dechlorination with, S 68
effect of chlorination practice on efficiency of, S 78

slurrying and feeding equipment for, S 72

taste and odor control with, Ap 78, S 80

organic; determination of, Je 90

Carbonic acid; formation of, in underground water, N 68

Cathodic protection; process of, Oc 78

Cave water; saline composition of, N 70

Channels; alluvial; design of, J1 74

open; motion in, Oc 92

Chemical Analysis, My 74, Je 90, J1 82, Oc 66**Chemical Feeding, Conditioning, and Sedimentation, S 68, N 78**

Chloride; electrometric determination of, Oc 86

photometric determination of, Oc 70

semimicro determination of, Oc 70

spectrophotometric determination of, Oc 70

titrimetric determination of, Je 92

turbidimetric determination of, Je 92

Chlorination; electrolytic; experiments with, N 80

nomogram for control of, Ap 66

Chlorine; bactericidal action of, compared with ozone, S 76

colorimetric determination of, My 78

effects of, on *Escherichia coli*, J1 62

free; effects of, on bacteria, J1 66

water treatment with, Ap 64

Chloropicrin; colorimetric determination of, Oc 70

Chromatography; application of, Oc 84

Cladocera; study of, in reservoir lakes, S 80

Coagulation; *see also* Flocculation

ferric chloride used in, S 74

polyelectrolytes as aids in, S 72

process of, N 78, N 80

treatment with, J1 82

Coastal waters; Pacific Ocean; survival of coliform organisms in, F 62

protective; formation of, for water conduits, Ap 74

seal; composition of, for boilers, Je 72

Coatings; silicate; phosphate-; advantages of, Oc 78

Coliform bacteria; *see* Bacteria

Columbia River; effects of radioactivity in, J1 80

Compounds; chemical; formation of, in underground water, N 68

unstable; determination of, Oc 88

Condensate systems; corrosion in, Oc 78

Construction; concrete; use of colloidal grout in, My 92

reservoir; method of, for Swansea, Wales, My 92

Control; polarographic; use of, to control corrosion, Oc 76

Cooling towers; protection of, against corrosion, Oc 80

Cooling water; reuse of, Je 76

Copper; colorimetric determination of, Je 92
corrosion of, in boilers, Je 68

diallyl thiocarbamide for determination of, My 78

photometric determination of traces of, Oc 70

Corrosion, Je 82, Oc 76*see also* Boiler water

Boilers and Feedwater

Couplings; use of, in plastic pipe, Ap 74

Cyanide; determination of, Je 92, My 84

Dairy water; bacteriologic aspects of, Ja 66

Dams and Reservoirs, My 88

Dealkalization; applications of, Oc 88

Debris; radioactive; removal of, from water, J1 78

"Decarbolith"; iron removal with, Ja 68

Dechlorination; activated carbon for, S 68

Demineralization; freezing method for, Oc 90

process of, Je 81

Denmark; Copenhagen; water treatment in, Ap 66

Dental caries; studies on, Au 72

See also Fluoridation

Desalting; electro-dialytic method for, Oc 90

Desilication; process of, by calcined dolomites, Je 81

(Continued on page 72 P&R)

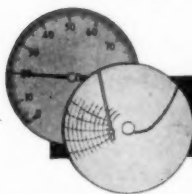
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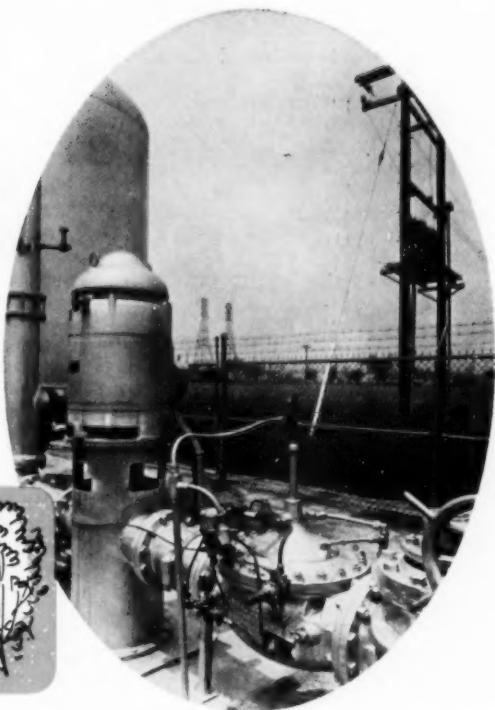
**Instrumentation and Controls
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(Continued from page 70 P&R)

- Detergents; effects of, mixed with quaternary ammonium, J1 62
- Disinfection, J1 62**
see also Chlorination
 use of, compared with boiling and filtration, J1 80
- Disodium salt; determination of metals with, Oc 72
- Distribution Systems, Ap 70**
- Dolomites; calcined; use of, in desilication, Je 81
 water treatment with, Ap 68
- EDTA; coliform index maintained by, S 76
- Electrolytes; action of, N 80
 removal of, Ap 66
- England; *see* Great Britain
- Enterococci; comparison of coliform bacteria with, in wells, F 62
- Escherichia coli*; removal of, by ozone and chlorine, J1 62
- Estuaries; stratification of waters in, J1 68
- Ethylene glycol; quantitative determination of, My 78
- Europe; pollution in, My 72
 water supply of, Au 78
- Evaporator tubes; boiler; corrosion of, Oc 78
- Eye Brook Reservoir; biology of, My 92
- Fallout; *see also* Radioactivity
 radioactive; effects on Massachusetts water, J1 80
 removal of, from water, J1 78
- Fermentation tubes; comparison of membrane filter method with, F 66
- Ferric chloride; use of, in coagulation, S 74
- Filter aids; development of, Ap 70
- Filters; biological; development of, N 66
 membrane; *see* Membrane filters
 pressure; high-rate; use of, J1 66
 rapid sand; design of, J1 68
 sand; cleaning methods for, N 66
 data on flow through, J1 68
 studies of, with radioactive tracers, J1 66
 sodium cationite; development of, N 66
 use of, in New South Wales, J1 62
- Filtration, Ap 68, J1 66, N 66**
 use of, compared with boiling and disinfection, J1 80
- Flocculants; new types of, N 80
- Flocculation; *see also* Coagulation
 effectiveness of various chemicals in, S 86
 effects of stirring on, S 68
 treatment with, J1 82, N 78
- Florida; Miami; sea water intrusion at, Au 86
- Flow; calculations of, J1 74
 data on, from electrical and membrane analogy, J1 74
 effects of solids on, J1 68
 electrochemical measurement of, J1 76
 experiments on, J1 70
 measurement of, J1 74, J1 76
 with radioisotopes, J1 74
 pipeline; measurement of, by aerofoil meter, J1 70
 studies of, in channels, Oc 94
 turbulent; description of, J1 78
- Flowmeters; magnetic; design and operation of, J1 78
 thermal; design and performance of, J1 74
- Fluorescence microscopy; estimation of bacteria with, F 68
- Fluoridation, Ja 62, Mr 65, Au 72, N 66**
- Fluoride; colorimetric determination of, My 78
 feeding of, Au 72
 microdetermination of, My 80
 spectrophotometric determination of, My 80
 state of, in drinking water, N 68
 topical application of, Mr 68
 urinary effects of, Au 74, N 68
- Fluorine; study of toxicity of, Mr 65
- Fluorosis; prevention of, Au 76
- Foreign Water Supplies—General, Ja 72, Au 76, N 74**
see also entries under specific countries
- France; Brittany; ground water geology of, Ja 70
 Saint-Etienne; water supply of, Au 84
- Gelatinous coatings; friction losses due to, Ap 76
- Generators; power; protection of, Je 76
 steam; corrosion of, Oc 80
- Georgia; study of algae in, My 64
- Germany; Berlin; surface and ground water interchange at, Au 86
 water supply of, Au 84
 chemical treatment in, J1 80
 consideration of fluoridation in, Mr 65
 Dusseldorf; water supply of, Au 78
 ground water resources and utilization in, Ja 70, Au 84
 Hesse; water supply of, Au 78
 phenolic wastes in, My 74
 proposed general water law for, S 86
 treatment practices in, Ap 66, Ap 68, Ap 78
 water supply in, Je 76, N 76

(Continued on page 74 P&R)

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(Continued from page 72 P&R)

- Great Britain; Broadside; use of filters at, Ap 70
 Caithness County; water supply of, Au 82
 consideration of fluoridation in, Mr 65, Mr 68
 control of stream pollution in, F 68
 data on water utilities in, Ja 72
 Egham; new chemical treatment at, Ap 66
 London; report on pollution research at, F 74
 Middlesex; new chemical treatment at, Ap 64
 Monmouthshire; water supply in, Ja 72
 Nottingham; water supply of, Au 82
 Penycae; water supply at, N 78
 Pitsford; water supply at, N 74
 southern; ground water geology of, Ja 70
 Torquay; water supply at, N 78
 treatment in, compared with US, Ap 68
- Ground Water, Ja 70, Au 84, N 68**
 filtration of, Ap 70
 physico-chemical analysis of, My 88
 pollution of, in Europe, My 72
 in Sweden, My 68
- Halides; direct potentiometric determination of, My 84
 flame photometric determination of, Oc 72
 Hardness; complexometric determination of, Oc 82
 palmitate determination of, Oc 82
 removal of, Je 81
 ternary diagram of, Oc 90
 trilometric determination of, Oc 84
 vereenata determination of, Oc 84
- Head loss; data on, during backwashing, J1 66
 nomographs for determination of, Mr 64
- Health and Hygiene, Ja 62**
 High-purity water; corrosive effects of, Je 82, Oc 80
 Humic substances; behavior of, N 80
 Hungary; ground water supply of, Au 78
- Hydraulics, Mr 65, J1 68, Oc 92**
 Hydrazine; use of, to prevent oxygen corrosion, Je 88
 Hydrocarbons; paraffin; determination of, in polluted water, My 86
 polynuclear; determination of traces of, J1 86
 Hydrogen; measurement of, in boilers, Je 74
 Hydrothermal water; determination of, from sea water, Au 90
 Hypochlorination; process of, N 78
- Illinois; Chicago; fluoridation system at, Mr 65
 Illinois (*contd.*); Evanston; fluoridation at, Au 74
 Rock Island; taste and odor control at, S 78
 Industrial supplies; treatment of, Ap 68
 Industrial wastes; protection of surface waters from, F 70
- Industrial Water Use, Je 74**
see also Boiler water; Boilers and Feed-water, Cooling water; Dairy water
 Industry; US; pollution control in, My 66
 Infrared spectra; differentiation of bacteria by, S 74
 Intrusion; sea water; Miami problem with, Au 86
 Iodide; titration of, with silver ion, Mr 72
 Iodine; determination of, My 84
 Ion exchangers; *see also* Demineralization; Hardness; Softening
 anionic; use of, in hydrochemical analysis, My 88
 cationic; applicability of, Je 80
 costs of, Je 81
 cost data for, Je 81
 mixed-bed; comparison of various methods of softening with, Ja 66
 experiences with, Je 80
 portable; description of, Oc 90
 sulfonated-coal; softening with, Ja 66
 uses of, Je 76, J1 82, Oc 90
 with base-exchange materials, Je 80
 utilization of, Ja 68
- Irrigation; design of channels for, Oc 92
 development of, Au 86
- Iron; *see also* Softening
 determination of, Oc 72
 removal of, Je 78, Je 81
 by pressure method, Oc 90
 solubility of, in underground water, N 70
 systematic technological test for, Je 80
- Israel; survival of bacteria in soil of, F 66
 water supply in, Au 86, N 76
- Italy; Sicily; methemoglobinemia study in, Ja 64
- Japan; observations on radioactivity in, J1 78
 Tsubame City; pipe corrosion at, Je 90
- Laboratory Methods, Mr 68, Oc 80**
 Lead; diallyl thiocarbamide for determination of, My 78
 Legislation; Germany; proposed general water law, S 86
 US; pollution control, S 86
 Lime; production and handling of, N 80
 stabilization of water softened with, Ja 68
 Lime-soda; use of, in water softener, Oc 90

(Continued on page 76 P&R)

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(Continued from page 74 P&R)

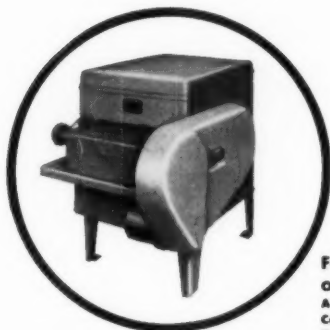
- Magnesium; complexometric determination of, Oc 70
 photometric determination of, Mr 74
 Maine; Norway; fluoridation at, Ja 64
 Malta; water supply of, Au 84
 Manganese; removal of, Je 78, Je 81
 Mannitol bile broth; coliform-bacteria identification with, S 74
Streptococcus faecalis identification with, S 76
 Massachusetts; Danvers; microstraining equipment at, N 66
 development of ground water supplies in, Au 86
 Falmouth; concentrations of phytoplankton at, My 62
 fluoridation in, Ja 64
 radioactivity of surface waters in, J1 80
 Materials; structural; studies in corrosion of, Je 84
 Measurement; water level; electronic equipment for, Oc 94
 Membrane filters; comparison of fermentation tube method with, F 66
 technique for microscopic count with, F 66
 use of, in pigment analysis of plankton, My 62
 Metals; structural; corrosion of, in high-purity water, Je 82
 Meters; comparisons of, J1 74
 corrosion of, Je 88
 Methemoglobinemia; Sicilian study on, Ja 66
 Michigan; Grand Rapids and Muskegon; fluoridation at, Au 72, Au 76, N 66
 Microstraining; equipment for, N 66
 Molasses; use of, in cleaning boilers, Je 72
 Molecular filter method; *see* Membrane filters
 Municipal supplies; *see specific states, provinces, and countries*
 Netherlands; water supply in, N 76
 Nevada; Pershing County; ground water resources of, Ja 70
 New Brunswick; fluoridation in, Au 74
 New York; Newburgh; fluoridation at, Ja 62, N 66
 New Zealand; Manukau Harbor; bacteriological survey of, F 62
 Wellington Harbor; bacteriological survey of, F 66
 Nickel; diallyl thiocarbamide for determination of, My 78
 Nitrates; colorimetric determination of, Oc 72
 determination of, in pond water, Oc 72
 Sicilian study on relation of methemoglobinemia to, Ja 66
 Nitrogen; ammonia-; photo-colorimetric determination of, Oc 66
 determination of, in waste waters, My 84
 North Carolina; pollution control in, S 86
 Ohio; Berea; taste and odor control at, Ap 78
 Ontario; Brantford; fluoridation at, Ja 62, Mr 65, N 66, N 68
 Oxidation; dichromate; method of, Mr 72
 Oxidation ponds; sewage; growth of algae in, My 66
 Oxygen; corrosion of, prevented by hydrazine, Je 88
 dissolved; colorimetric determination of, My 86, Oc 72
 determination of, J1 82, J1 86
 removal of, with nitrogen, Ap 68
 electrochemical determination of, My 84
 microcolorimetric determination of, Mr 74
 removal of, from boiler water, Je 72
 Ozonation; treatment with, in Switzerland, Ap 66, Ap 68
 Ozone; bactericidal action of, compared with, chlorine, S 76
 effects of, on *Escherichia coli*, J1 62
 Pennsylvania; Midland; taste and odor control at, Ap 78
 Permutite; preparation of, Je 81
 Phenols; determination of, in wastes from distillation of coal, My 88
 removal of, by adsorption of fly ash, F 70
 Phosphates; determination of, in boiler water, Je 72
 well water stabilization with, S 68
 Phosphorus; colorimetric determination of, Oc 76
 Pigment analysis; use of membrane filters for, My 62
 Pipe; comparison of materials for, Ap 74
 studies on corrosion of, in Japan, Je 90
 Plankton; annual cycle of, in reservoir, S 84
 chlorophyll as index of, S 84
 concentrations of, at Falmouth, Mass., My 62
 estimation of, by use of membrane filters, My 62
 studies of, in southwest Georgia, My 64
 zymogenic; ecology of, My 62
 Plastic pipe; couplings for, Ap 74
 development of, Ap 74
 Pleisse Dam; observations of water at, My 88
 Pollution and Pollution Control, F 68, My 66, S 86
 comparison of indexes for, S 77

(Continued on page 78 P&R)

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(Continued from page 76 P&R)

- Pollution (*contd.*); evaluation of anaerobes as index of, S 77, S 78
stream versus effluent standards for, S 86
- Radioactive tracers; use of, in studying rapid sand filtration, J1 66
- Radioactivity, J1 78**
treatment of, with new mobile unit, J1 78
- Radiocarbon; coliform-bacteria detection with, S 77
- Radioisotopes; use of, to measure flow, J1 74, J1 76
- Recharge; aquifer; uses of, Au 84
ground water; problems of, N 70
- Reuse; aspects of, in industry, Je 76
- Rhine River; taste and odor in water of, Ap 76
- Rhodesia; Lusaka; water supply at, N74
- Rinse waters; metal-plating; control of, F 70
- River water; filtration of, Ap 70, N 66
- Rural areas; control of water delivery for, Mr 64
- Salinity; sea water; measurement of, Oc 82
- Salmonella tennessee*; survival of, in Israel soil, F 66
- Scale; boiler; composition of, Je 72
prevention of, Je 66
- Scotland; water supply of, Au 84
- Sea water; determination of, from hydrothermal water, Au 90
survival of enteric organisms in, F 62
- Sedimentation; calcareous; physiochemical study of, N 80
process of, N 78
- Sediments; natural; estimation of, My 68
studies in, Oc 92
- Severn River; treatment of water of, J1 82
- Sewage; effects of, on aquatic organisms, My 64
- Sewage disposal; hydraulic aspects of, Mr 64
- Shortages; alleviation of, by use of ground water, Au 86
- Sicily; studies of fluorosis and caries in, Mr 68
- Silica; control of, in boiler water, Je 72
removal of, by filtration, Ap 68
removal of, through alkaline materials, Ap 70
residual; determination of, Oc 84
- Slurries; sand; experiments on flow of, J1 68
settling; data on flow of, J1 68
- Softening and Iron Removal, Ja 66, Je 78, Oc 88**
see also Demineralization; Hardness; Ion exchangers
- Solids; dissolved; removal of, Je 81
- Spectrochemical analysis; process of, Oc 80
- Stream flow; factors affecting velocity of, J1 68
- Streptococcus faecalis*; survival of, in Israel soil, F 66
- Substances; organic; chromatographic determination of, Oc 88
- Sulfate; determination of, by reducing to hydrogen sulfide, My 88
nephelometric determination of, Mr 72
volumetric determination of, Oc 76
- Sulfide; hydrogen; characteristics of, J1 82
- Surface water; conditions of, in Berlin, Au 86
pollution of, in Europe, My 72
- Surge; *see* Hydraulics
- Surveys; stream pollution; costs of, F 74
- Suspended-solids contact basins; description of, S 72
- Sweden; pollution of ground water in, My 68
- Switzerland; Aare River, pollution of, My 74
Bernese Oberland; algae in waters of, My 64
ozonation in, Ap 66, Ap 68
- Taste and Odor, Ap 76, S 78**
- Texas; Bartlett; fluoridation at, Mr 68
Galveston County; ground water resources of, Ja 70
- Titration; coulometric; method of, with silver ion, Mr 68
- Titrimetry; technique for, My 78
- Tracers; ground water; evaluation of, N 70
- Treatment—General, Ap 64, J1 80**
see also under various types of treatment
- Treatment systems; chemical; protection of, against corrosion, Je 68
- Trilometry; applications of, Oc 88
- Tritium; estimation of, Mr 72
- Tropics; water treatment in, Ap 64
- Ultrasonic waves; experiments in softening by, Je 78
influence of, on calcium carbonate formation, Oc 90
- United States; *see entries under specific states*
general review of fluoridation in, Mr 68, Au 72
pollution control in industries of, My 66
- Upflow basins; *see* Suspended-solids contact basins
- Uranium; quadrivalent; use of, as reducing agent, My 78
- Urochrome; characteristics of and tests for, J1 86

(Continued on page 80 P&R)



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(Continued from page 78 P&R)

- Uruguay; Montevideo; analysis of water in, My 88
- USSR; control of pollution in, F 70
- Valves; *see also* Hydraulics
discharge coefficients for, J1 76
- Venezuela; Caracas; water supply at, N 76
- Venturi canals; design of, Oc 92, Oc 94
- measurement of delivery in, Mr 64
- Vietnam; Saigon; iron removal at, Ja 68
- Wales; Swansea; construction of reservoir for, My 92
- water supply in, Ja 72, N 74
- Wastes; dairy; control and treatment of, F 70
- organic; effects of, on taste and odor, Ap 78
- indications of, by distribution of aquatic organisms, My 62
- phenolic; pollution by, in Germany, My 74
- treatment of, F 70
- Water composition; effects of, on corrosion, Je 88
- Water hammer; *see also* Hydraulics
influence of velocity change on, Mr 64
- Water mains; protection of, against corrosion, Oc 76
- Water spreading; methods of, Au 86
- Water supply; data on, for industry, Je 74, Je 76
- Weir Wood Reservoir; description of, My 92
- Weirs; overflow; use of, J1 74
- portable; description and use of, Mr 65
- Well water; phosphates for stabilization of, S 68
- Wells; comparison of coliform bacteria with enterococci in waters from, F 62
- hydraulics of, Oc 94
- Wells and Ground Water, Ja 70, Au 84, N 68**
- White water; clarification of, by magnetic process, My 68
- Zeolites; applications of, Oc 90
- Zinc; colorimetric determination of, with dithizone, Oc 76
- diallyl thiocarbamide determination of, My 78

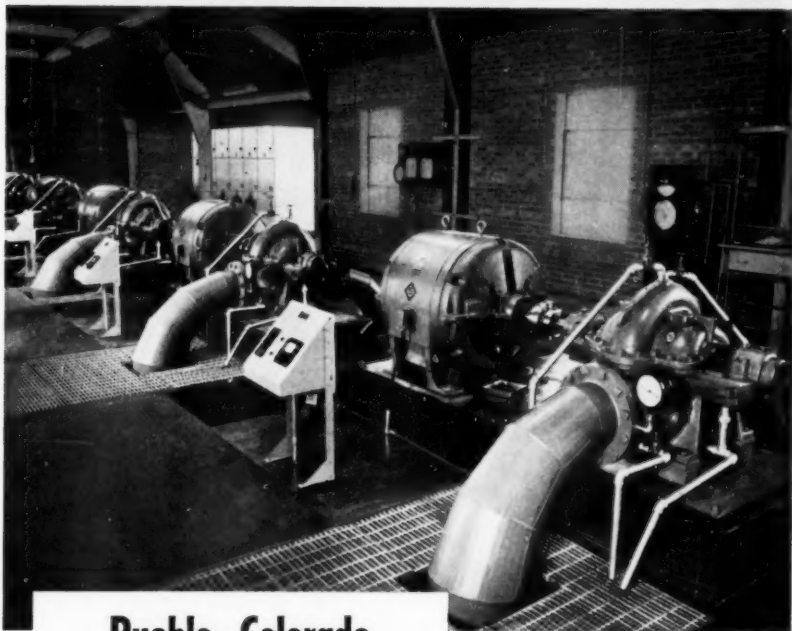
Authors of Abstracted Articles

Page numbers refer to P&R section of Journal. Letters in italics immediately preceding page numbers refer to month of issue, in accordance with following key: Ja—January; F—February; Mr—March; Ap—April; My—May; Je—June; Jl—July; Au—August; S—September; Oc—October; N—November.

- ABAZAEV, E. S., S 74
- ABBOTT, M., J1 68
- ACHTEN, M., Je 81
- ADAMS, D. F., My 80
- ALLEN, M. B., My 66
- ALPER, T., S 74
- AMBUHL, H., My 84
- ANDERS, H., My 88
- ANDREWS, W. L., Je 68
- APPA, ROA U., Je 72
- APPLEBAUM, S. B., Je 78
- ARCHER, E. E., My 88
- ARNOLD, F. A., Jr., Au 72
- AST, D. B., Ja 62
- BABKIN, R. L., Ja 68
- BAIER, C. R., Au 84
- BAKER, W. A. R., Au 82
- BALLOFFET, A., J1 76
- BARRETT, M. J., Au 72
- BAUMANN, E. R., Oc 72
- BAUMANN, P., Au 84
- BAYLIS, J. R., Mr 65, Ap 76, J1 66
- BEAN, E. L., Ap 64
- BEATTY, K. O., J1 76
- BEAUJEAN, P., Ap 70
- BEISOVA, M. P., Oc 84
- BELL, G. R., Ap 70
- BENEDEN, G. V., N 80
- BENES, M., F 70
- BERRY, A. E., Au 74
- BERTRAND, P., Oc 70
- BIEMOND, I. C., N 76
- BILANDEAU, A. L., Je 76
- BLANC, P., Oc 70
- BLOKH, S. S., S 72
- BOCK, R. O., J1 74
- BOGNAR, J., Je 92
- BOORSMA, H. J., N 70
- BORECKY, G. W., S 80
- BORLAND, W. M., Oc 92
- BORZOVA, D., My 78
- BOS, H. M., Ap 74
- BRADSHAW, A., Oc 82
- BRAMER, H. C., My 68
- BRANDEL, A. J., Je 76
- BRAUSS, F. W., N 80
- BREDEN, C. R., Je 82

(Continued on page 82 P&R)

Allis-Chalmers **PUMPS** solve a water works problem



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two 12 by 10 SHS pumps, 3500 gpm, 290-ft head,
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You draw on Allis-Chalmers wide experience in supplying pumps for public works . . . for expert engineering and application help. You get pumps made of best-quality materials, of heavy duty construction, of high-efficiency design. Allis-Chalmers is the only company that offers you "one source" responsibility, with a complete unit — pump, motor and control — all built to work together — all built by Allis-Chalmers.

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A-1290

ALLIS-CHALMERS

(Continued from page 80 P&R)

- BREUER, H., *Mr* 74
 BRODSKII, A. A., *N* 68
 BROWN, H. B., *Je* 76
 BROWN, H. K., *Ja* 62
 BROWN, P. E., *Je* 88
 BRYANSKII, B. D., *Je* 81
 BUCHAN, S., *My* 72
 BUDANOVA, L. M., *Oc* 72
 BURBANK, N. C., JR., *Jl* 78

 CALISE, V. J., *Je* 81
 CALLAGHAN, C., *S* 68
 CARLSON, E. J., *Oc* 92
 CEFALU, M., *Ja* 66
 CEJKA, M., *Ja* 66
 CERVENKA, R., *Oc* 70
 CHACINSKI, T. M. P., *Oc* 92
 CHEBOTAREV, I. I., *Ja* 72
 CHIEN, N., *Jl* 74
 CHITTY, T. C., *Jl* 78
 CHOSSAT, H., *Je* 72
 CHRIST, W., *Oc* 78
 CHUGUNOV, V. S., *Ap* 68
 CLARK, R. N., *Jl* 80
 CLARKE, J. H. C., *Mr* 65
 CLEGG, L. F. L., *Jl* 62
 CLERFAYT, A., *N* 74
 CLODIUS, *Je* 76
 COATE, R., *S* 80
 COBURN, C. I., *Au* 72
 COLE, E. C., *N* 76
 COLL, H., *Oc* 70
 COLVIN, D. E., *Jl* 68
 CONSTANTINE, T., *Jl* 78
 COOPER, G. N., *S* 76
 COOPER, R. L., *Jl* 86
 CORNISH, M. I., *Jl* 62
 COUSINS, C. M., *Jl* 62
 COWAN, B. W., *Au* 74
 CREITZ, G. I., *My* 62
 CRUMP, E. S., *Oc* 94
 CUNNINGHAM, W. A., *Je* 76
 CURRY, R. P., *My* 78
 CUTHBERT, W. A., *Ja* 66
 CYPRES, R., *Oc* 90
 CZENSNY, R., *Oc* 84
 CZERKINSKI, S. N., *F* 70

 DALBKE, R. G., *Oc* 78
 DALE, J. N., *Au* 82
 DALLA VALLE, J. M., *N* 78
 D'AMBOSIO, G., *Ja* 66
 DANFORTH, C. A., *N* 80
 DAVID, M. M., *Je* 81
 DAVIES, I., *Jl* 82, *Oc* 70
 DAVYDOV, A. T., *Je* 81
 DE ALDERUCCIO, H. V. A., *Oc* 84
 DEK, W. E. A., *Mr* 64

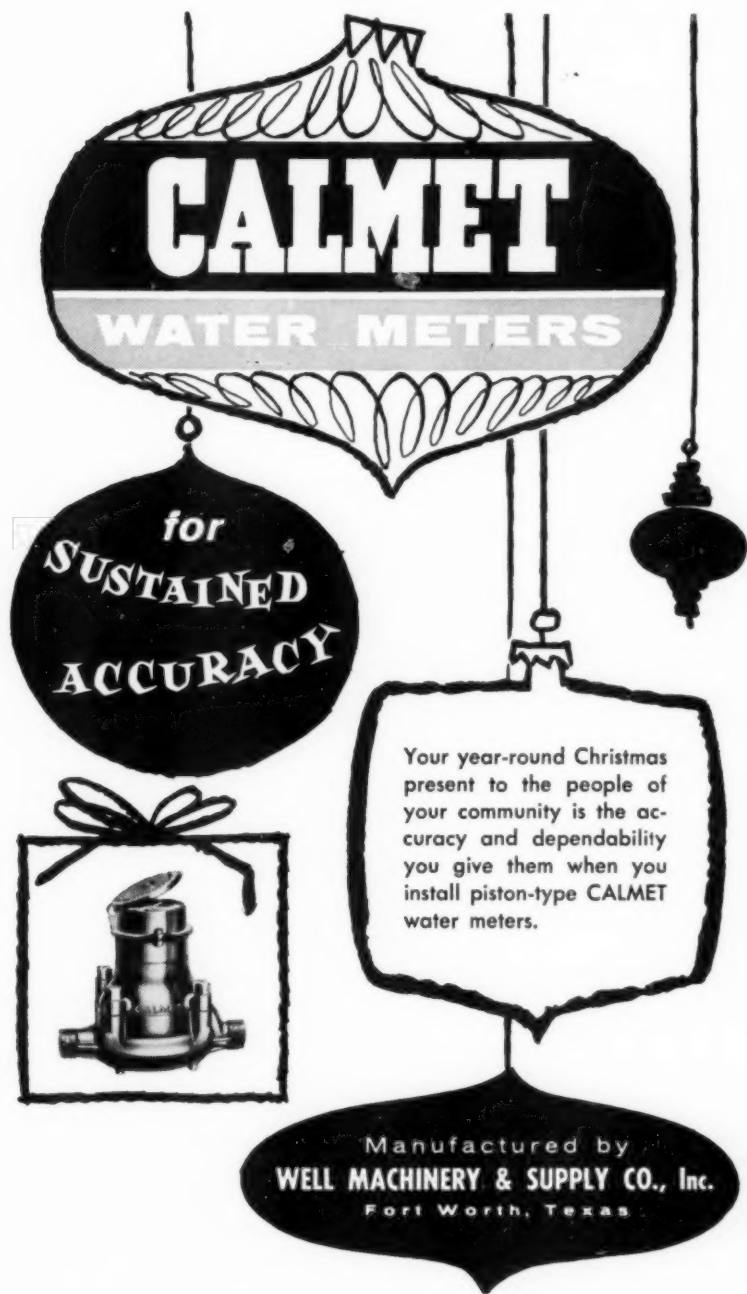
 DE KRUYFF, A., *Mr* 64
 DENHOLM, E. W., *Ap* 70
 DENMAN, W. L., *Oc* 80
 DE PAUL, D. J., *Je* 82
 DE RUELLA, L. B., *Oc* 84
 DESCHAMPS, P. M., *Oc* 86
 DIEHL, H., *My* 74
 DIETZ, R. F., *Je* 81
 DIRSCHERL, W., *Mr* 74
 DIVIS, L., *Je* 92
 DOSCH, F., *Jl* 62
 DOUDERT, J., *N* 66
 DRANE, C. W., *Ap* 66
 DRESSCHER, T. G. N., *S* 77
 DRIZ, I. A., *N* 80
 DUBIN, C., *Ap* 76
 DU PRE, E. F., *S* 74
 DUROV, S. A., *N* 70
 DUTT, N. K., *My* 78
 DYATLOVITSKAYA, F. G., *My* 88

 ECKEL, J. F., *Je* 82
 ECKSTEIN, *Ja* 68
 EHRLICH, R., *F* 66, *F* 68
 EHRLMANTRAUT, H. C., *F* 68
 ELIASSEN, R., *Jl* 78
 ELLINGBOE, J. L., *My* 74
 EMERSON, A. G. D., *Ap* 74
 EMMENEGGER, T., *F* 68

 FAIRING, J. D., *Oc* 66
 FARRINGTON, P. S., *Mr* 72
 FELDMAN, I., *N* 68
 FERRELL, J. K., *Jl* 76
 FETNER, R. H., *Jl* 62
 FIELDS, A., *S* 76
 FILICKY, J. G., *Ap* 78
 FINNEGAN, T. J., *Oc* 80
 FISHER, D., *Oc* 70
 FISS, E. C., *Je* 88
 FLANDERS, P. H., *S* 74
 FLOYD, A. W., *Oc* 90
 FLOYD, K. L., *Oc* 90
 FOGG, G. E., *S* 86
 FOREST, J. R., *Ja* 62
 FORREST, J. R., *Mr* 68, *N* 66
 FORSLAD, I., *Je* 90
 FOURNIER, R. M., *Oc* 70
 FRIBERG, L., *Jl* 66
 FRIEDMAN, C. B., *Oc* 80
 FRIEND, W. Z., *Je* 84
 FROGER, P., *Jl* 76
 FUCHS, W., *Je* 68
 FURTUNESCU, H., *Je* 68

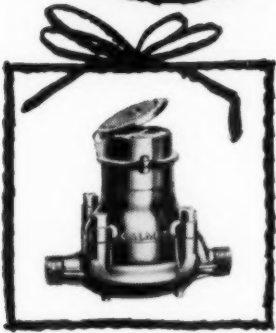
 GAD, G., *My* 84
 GALAGAN, D. J., *Mr* 68
 GALIMBERT, G. M., *Au* 72

(Continued on page 84 P&R)



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(Continued from page 82 P&R)

GAMESON, A. L. H., *F* 68
 GARCELON, A. H., *Au* 74
 GARCELON, A. W., *Ja* 64
 GARDET, E., *Mr* 64
 GARDINER, A. N., *Ja* 72
 GARNELL, M. A., *S* 72
 GARNER, M. Q., *Oc* 70
 GARVER, R. M., *F* 62
 GAUFIN, A. R., *My* 62
 GERB, L., *Au* 90
 GERRIE, N. F., *Au* 76
 GINZBURG, D. B., *Je* 72
 GLUSHENKO, V. V., *Je* 72
 GOLTERMAN, H. L., *Oc* 72
 GORBENKO, F. P., *Oc* 66
 GOTAAS, H. B., *Oc* 92
 GOTTLIEB, O. R., *My* 78
 GRABOWSKI, H. A., *Je* 66
 GRAINGER, R. M., *Au* 72
 GRANT, W., *Ap* 78
 GRASER, R., *Je* 68
 GREENBERG, A. E., *F* 62
 GREENBERG, S., *Je* 82
 GREY, F. J., *Ja* 64
 GUILD, A. E., *Ja* 72
 GUINOT, H., *F* 70
 GUNTHER, G., *Je* 90
 GURNEY, H. C., *S* 77
 GUYARD, *Mr* 64

HAIM, A., *My* 84
 HAMER, P., *Je* 66
 HAMMARSTROM, E., *Jl* 66
 HANEY, P. D., *N* 78
 HANLON, R. T., *Je* 72
 HARDING, H. G., *F* 70
 HARRISON, V. R., *S* 77
 HART, W. B., *S* 86
 HAYES, R. L., *Au* 76
 HENDERSON, C., *Jl* 80
 HENDRIKSEN, S. D., *S* 74
 HENKE, E. W., *Je* 88
 HERMAN, A., *N* 70
 HERMANOWICZ, W., *Je* 80
 HESS, E. R., *My* 78
 HESS, R. W., *Oc* 66
 HESS, W. C., *S* 77
 HETTICHE, H. O., *Jl* 86
 HIEBENTHAL, F., *Jl* 82
 HIRSCH, A. A., *Ja* 68
 HLUCHAN, E., *Oc* 72
 HOAK, R. D., *My* 68
 HODGE, H. C., *N* 68
 HOFER, K., *Ap* 78
 HOFER, P., *Jl* 80
 HOLLIS, M. D., *S* 86
 HOLUTA, J., *Ap* 76, *Oc* 88
 HOLNESS, H., *Oc* 80

HOPKINS, E. S., *S* 76
 HOPKINSON, G., *Oc* 70
 HORASAWA, I., *Je* 90
 HORNUNG, H., *Mr* 65
 HOUSE, H. P., *Oc* 72
 HOUSE, R., *Oc* 66
 HUBIE, J., *Je* 72
 HUNERBERG, K., *Au* 84
 HURLBURT, E. M., *My* 62
 HUTTON, W. L., *N* 68
 HYNDSBOW, A. Y., *S* 78

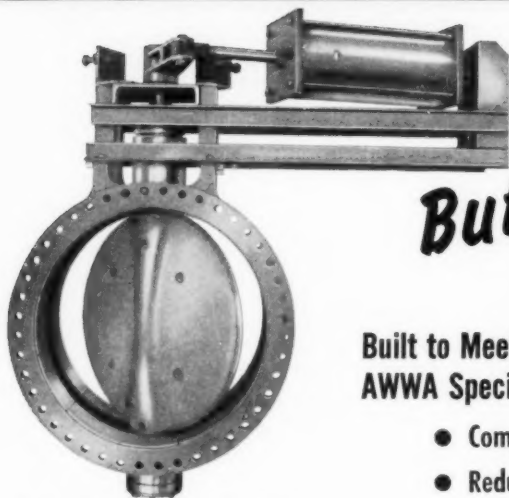
INGOLS, R. S., *Jl* 62
 ISAAC, P. C. G., *Ap* 68
 ISSA, I. M., *My* 78
 IVES, K. J., *Ap* 78, *S* 84
 IWATO, T., *Je* 90

JAAP, E. Z., *Jl* 86
 JANNASCH, H. W., *My* 62
 JARRETT, J. M., *S* 86
 JENKINS, W. A., *Mr* 78
 JEROME, J. L., *F* 62
 JOHANNESSEN, J. K., *F* 66
 JOHNSON, C. E., *S* 72
 JOLLANS, W. M., *Au* 82
 JONES, D. A., *F* 74
 JORDAN, C. B., *My* 78
 JUDA, W., *Ap* 66

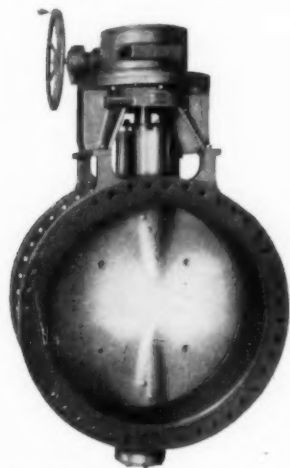
KAHLER, F. H., *Je* 81
 KAR, J., *N* 74
 KASINOV, B. E., *N* 66
 KAUFMAN, W. J., *N* 70
 KAZMIN, A. I., *Oc* 76
 KEHR, F., *Au* 76
 KELUS, J., *Je* 80
 KENNEDY, J. H., *Mr* 72
 KERVAN, L., *Oc* 90
 KEY, A., *My* 72, *N* 70
 KIEKENBERG, H., *Je* 74
 KITANO, Y., *Je* 92
 KLAFFKE, K., *S* 80
 KLYACHKO, V. A., *Je* 81
 KNUDSEN, E. J., *Au* 74
 KO, R., *Oc* 80
 KOECK, H., *S* 86
 KOHL, O., *S* 86
 KOPPF, R. K., *My* 80
 KORBOVA, M., *Oc* 70
 KOSLOVA, N. L., *S* 72
 KOVARIK, M., *Oc* 70
 KOWALKOWSKI, R. L., *Mr* 72
 KRAUSS, R. W., *S* 86
 KRAVITZ, E., *Jl* 62
 KRYUKOV, P. A., *Oc* 84
 KUCHARSKI, J., *Oc* 66
 KUL'BERG, L. M., *My* 78

(Continued on page 88 P&R)

SAVE SPACE — SAVE COSTS



AWWA 48", 125# valve for drop-tight shut-off at 100 psi. Renewable rubber seat; hydraulic cylinder operator.



AWWA 60", 50# valve for drop-tight shut-off at 35 psi water pressure. Cast iron body with spool type rubber liner; with worm gear and handwheel operator.

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**Built to Meet All
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- Compact—Lighter Weight
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- Minimum Pressure Drop
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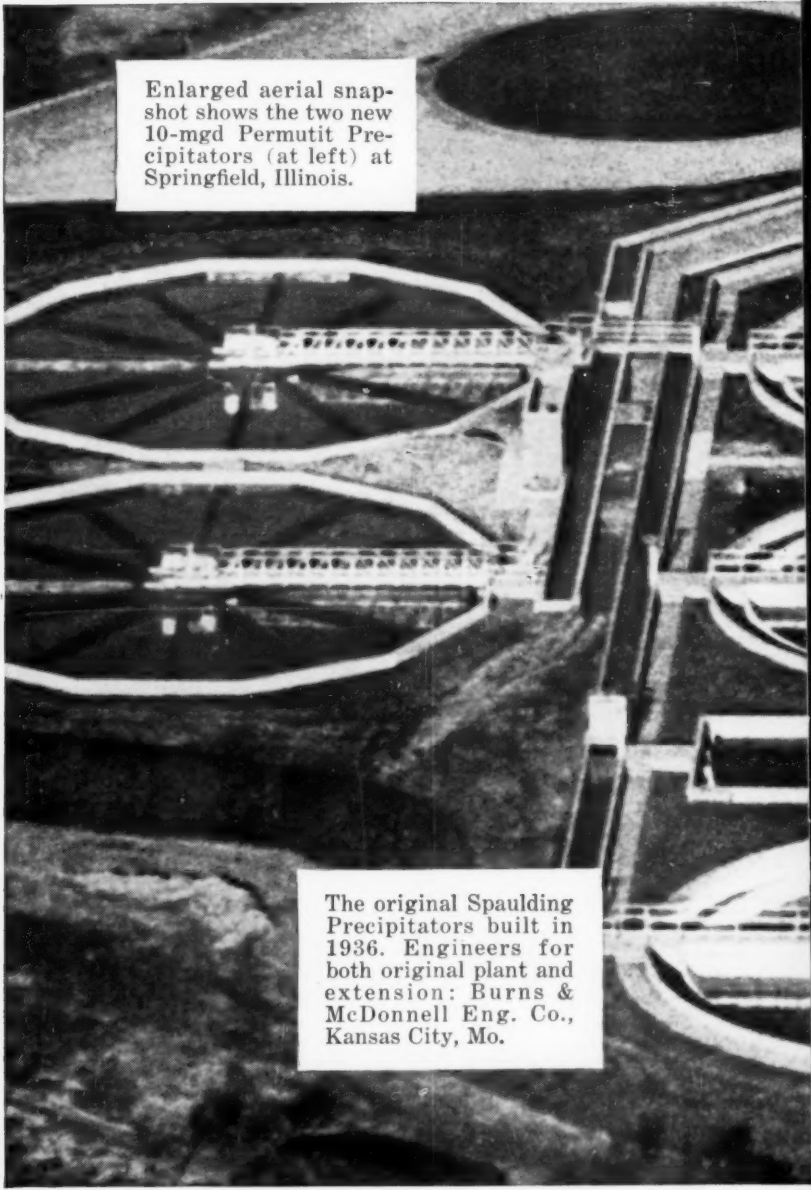
W. S. Rockwell Butterfly Valves are made in all standard sizes of cast iron, cast steel, stainless steel, bronze or other alloys; natural or synthetic gum rubber seat with clamping segments, or spool type rubber liner extending over flange faces. Operators—manual: AWWA nut, handwheel, chain wheel or other types; automatic: electric motor or cylinder. Write for Bulletin 574.



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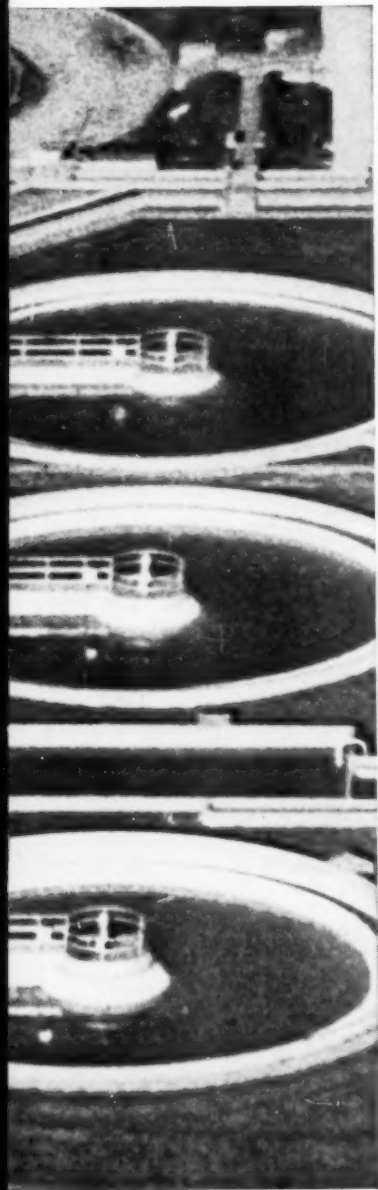
20-year record proves efficiency



Enlarged aerial snapshot shows the two new 10-mgd Permutit Precipitators (at left) at Springfield, Illinois.

The original Spaulding Precipitators built in 1936. Engineers for both original plant and extension: Burns & McDonnell Eng. Co., Kansas City, Mo.

of upflow "Precipitators"



In 1936, Springfield built three short-detention, upflow softening-coagulation units newly developed by Charles H. Spaulding. From the start, the Spaulding-designed units showed high flow rates — many times faster than the old basin system, a uniform quality effluent that doubled filter capacity, a low chemical cost and a low maintenance cost.

When Springfield's recent expansion program called for doubling its water-treating capacity, city engineers had almost 20 years of proven performance to guide them, a longer performance record than is available with any other type of upflow, sludge-blanket unit. That's why Permutit Precipitators based on Spaulding designs were chosen for the new units.

For complete details on any type of water conditioning equipment, write: The Permutit Company, Dept. JA-12, 50 W. 44th St., New York 36, or Permutit Company of Canada, Ltd., Toronto 1, Ont.

PERMUTIT

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Water Conditioning

Ion Exchange • Industrial Waste Treatment

(Continued from page 84 P&R)

KULSKII, L. A., *Jl* 82
 KUMPF, *N* 76
 KUZNETSOVA, Z. I., *Oc* 88
 LACKEY, J. B., *My* 64
 LAMONDS, H. A., *Jl* 76
 LANGSTAFF, R. D., *Oc* 80
 LA PAIX, M. A., *Ja* 68
 LAUDERDALE, R. A., *Jl* 78
 LECLERC, E., *Ap* 70
 LECOQ, H., *Oc* 84
 LEEMING, J. C., *Au* 84
 LEGRAYE, M., *N* 74
 LEICK, J., *Je* 80
 LENA, E. M., *My* 88
 LESZKO, M., *Je* 81
 LEVIN, G. V., *S* 77
 LEY, J. B. K., *Au* 78
 LIANDIER, L., *Oc* 70
 LIEBS, W., *Jl* 74
 LIKINS, R. C., *N* 68
 LINGANE, J. J., *Mr* 68
 LINSCHOTT, B. W., *N* 68
 LIPPERT, F., *Au* 86
 LIPPKE, M., *Jl* 74
 LITTLETON, N. W., *Au* 76
 LOELTZ, O. J., *Ja* 70
 LOHR, E. W., *Je* 74
 LONGWELL, J., *Mr* 68
 LOOMIS, W. F., *Mr* 74
 LOTHE, J. J., *My* 80
 LOVE, S. K., *Je* 74, *Je* 76
 LOVETT, M., *S* 86
 LUDZACK, F. J., *My* 86, *Je* 92
 MACAK, J., *F* 70
 MACMILLAN, W. G., *Oc* 82
 MAC NULTY, B. J., *My* 80
 MAGEE, V., *S* 68
 MAGUIRE, J. J., *Je* 76
 MALZAC, A. C., *Ap* 68
 MAMONTOV, K. A., *Oc* 90
 MAMET, A. P., *Je* 72
 MANDY, P., *Je* 78
 MANITA, M. D., *Oc* 76
 MARKS, R. H., *Je* 81
 MARSHALL, N., *S* 84
 MARTIN, R. E., *F* 66
 MATHER, J. M., *Mr* 65
 MATSUMOTO, J., *Je* 90
 MATVEEV, M. A., *Je* 72
 MAXWELL, P. M., *Oc* 66
 MAYER, J., *Oc* 72
 McCAFFREY, C. J., *Jl* 62
 McCall, E. R., *S* 74
 McCALLUM, G. E., *S* 86
 McDONALD, H. R., *Au* 86
 MCGILL, J. F., *Ja* 66

McCLURE, F. J., *N* 68
 McQUATE, A. G., *S* 84
 McRAE, W. A., *Ap* 66
 MEISSNER, B., *My* 88
 MELLON, M. G., *My* 78
 MELSENDER, F. W., *Oc* 66
 MENIS, O., *Oc* 72
 MESCERY, K., *Ap* 68
 MESSIKOMMER, E., *My* 64
 MESSINEVA, M. A., *Ap* 78
 METZLER, W., *Ja* 66
 MICHELS, F., *Au* 78
 MIDDLETON, F. M., *Ap* 78, *Oc* 66
 MIGNOT, *Mr* 64
 MILES, M. A., *S* 78
 MILLER, C. R., *Oc* 92
 MILLS, W. C., *Je* 76
 MINNICK, L. J., *N* 80
 MIRASSOU, M. G., *Au* 84
 MITRA, M. C., *Oc* 82
 MIYAKE, Y., *Jl* 78
 MOEHL, K. E., *Au* 86
 MOHLER, J. B., *F* 70
 MONET, G. P., *Je* 80
 MOORE, W. A., *Je* 92
 MORIN, P., *Mr* 65
 MORKAN, D., *N* 68
 MOSER, Z., *Je* 81
 MURTY, G. V. L. N., *Je* 72
 NEWITT, D. M., *Jl* 68
 NEWMAN, L. E., *F* 62
 NIELSCH, W., *Oc* 82
 NOISSETTE, G., *My* 88
 NOLL, D. E., *Je* 76
 NORDELL, E., *Ja* 68, *Ap* 68, *Oc* 70
 NOWAK, Z., *Oc* 76
 NUSBAUM, I., *F* 62
 O'CONNOR, R. T., *S* 74
 OLIVE, J. R., *S* 84
 OLIVE, M. J., *Oc* 78
 OLIVER, G. C. S., *My* 92
 ONGMAN, H. D., *Je* 66
 ORLOB, G. T., *N* 70
 OULMAN, C. S., *Oc* 72
 PAGANO, V., *Mr* 68
 PAGE, P. H. F., *N* 74
 PALANGE, R. C., *Jl* 80
 PAPE, C. H. V., *Ap* 70
 PARTRIDGE, E. P., *Je* 76
 PATTON, J., *My* 74
 PEAK, R. F., *Je* 81
 PECK, G. C. A., *Jl* 70
 PENKA, M., *Au* 90
 PERLINA, A. M., *S* 72
 PERSON, M., *Oc* 70

(Continued on page 90 P&R)



WHEN RED WATER DISAPPEARED . . . complaints turned to compliments

In a pleasant western community of about 40,000 population, constant complaints about red water made life miserable for the water superintendent. All that has changed, now that Calgon is on the job. In fact, he tells us "Perfect strangers stop me in the street to compliment me on the crystal clear water this community now enjoys."

Red water has stopped because Calgon* Threshold treatment stabilizes iron and manganese dissolved in well water at its source. The red (or black) water problem is licked, and the capital expenditure for a costly iron removal plant avoided.

Calgon is the easy and economical

way to keep your citizens or customers happy if your well water supply contains iron or manganese.

Calgon engineers with experience in all types of water problems in all parts of the country are at your service. A letter or phone call will put a Calgon engineer to work on your water problem.

*Calgon is the Registered Trade Mark of Calgon Company for its glassy phosphate (Sodium hexametaphosphate) products.

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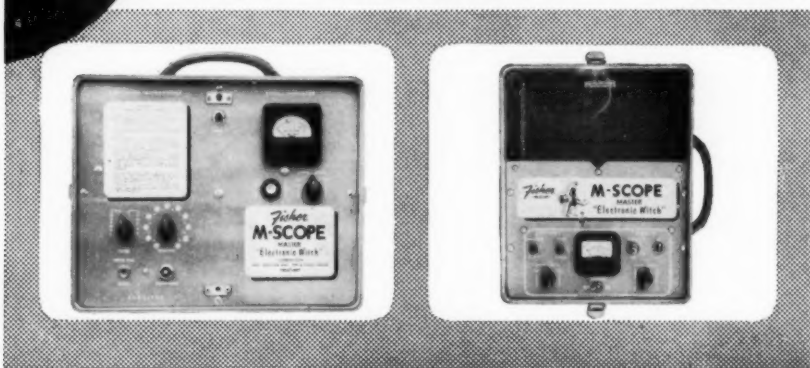
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HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES

(Continued from page 88 P&R)

- PETER, Y., *Au* 86
 PETERSON, D. F., *Jl* 74, *Oc* 94
 PETITT, B. M., Jr., *Ja* 70
 PHOENIX, D. A., *Ja* 70
 PIRETTI, J. G., *N* 76
 PLATONOVA, O. P., *Oc* 72
 PLATZL, M., *Jl* 76
 POLYAKOV, M. P., *N* 70
 POTTER, E. C., *Oc* 78
 POWELL, S. T., *Je* 76
 PRITCHARD, H. V., *Au* 74
 PROFIT, A., *Jl* 68
 PRYOR, W. A., *Au* 90
 PUGH, N. J., *Jl* 82
 QUINLEY, R. L., *F* 62
 RABINOWITZ, S. B., *F* 66
 RADER, E. M., *Au* 86
 RAFFAY, H. B., *Jl* 76
 RAINS, T. C., *Oc* 72
 REED, E. B., *S* 84
 REEDER, W., *My* 74
 REENTS, A. C., *Je* 81
 REES, R. L., *Oc* 78
 REID, E. F., *Ap* 64
 REID, J. D., *Au* 72
 RELF, E. T., *Je* 72
 RICH, L. G., *F* 74
 RICHARD, C., *Ja* 68
 RICHARDS, F. A., *My* 62
 RICHARDSON, F. M., *Jl* 76
 RICHARDSON, J. F., *Jl* 68
 RIEDL, R., *F* 70
 RIMBERG, E., *Oc* 88
 RITCHIE, A. R., *S* 68
 RITSCHL, H., *Ap* 68
 RITSCHL, H. O., *Ap* 68
 RITTER, C., *F* 62
 RIVERS, H. M., *Je* 76
 RIVIERE, A., *N* 80
 ROACH, A. W., *S* 78
 ROBECK, G. G., *Jl* 80
 ROEBUCK, A. H., *Je* 82, *Je* 84
 ROGOVSKAYA, T. I., *F* 66
 RONAI, A., *Au* 78
 RONNEBECK, H. R., *Jl* 74
 ROOYEN, C. V., *N* 76
 ROSEN, A. A., *Ap* 78
 ROSENTHAL, B. L., *Jl* 80
 ROSS, H. K., *My* 78
 ROSS, J., *Oc* 66
 ROSS, M., *Au* 84
 ROSSUM, J. R., *Je* 81
 ROVAL, G., *Jl* 66
 RUCHHOFF, C. C., *Je* 92
 RUMPF, A., *Ap* 70
 RYCROFT, J. A., *S* 76
 SAIDAKOVSKII, S. Z., *Au* 90
 SAILER, R. E., *Mr* 64
 SALEE, E. M., *Oc* 66
 SAMS, C. E. R., *Jl* 70
 SAREDO, J. E., *My* 84
 SARMA, K. P. S., *My* 78
 SAUER, K., *My* 74
 SCHAMBERGER, K. H., *S* 76
 SCHENK, P., *Au* 78
 SCHEURING, L., *S* 77
 SCHIFF, L., *Au* 86
 SCHLEICHER, K. E., *Oc* 82
 SCHLESINGER, E. R., *Ja* 62
 SCHLICHTING, H., *My* 84
 SCHOELLER, H., *Ja* 72
 SCHOELLER, M., *N* 70
 SCHOFIELD, J. C., *Au* 90
 SCHRODER, G., *Ap* 74
 SCHULZ, N. F., *Mr* 72
 SCHUMACHER, G. J., *My* 64
 SCHUMANN, E., *Ap* 70
 SCHWILLE, F., *Oc* 90
 SCRASE, H. F. J., *Oc* 84
 SEAMON, J. M., *Je* 88
 SEDDON, H., *My* 92
 SHELLENBERGER, R. D., *Ap* 78, *S* 80
 SHEMYAKINA, O. N., *Ap* 68
 SHERIF, I. M. E., *My* 78
 SHEVCHENKO, M. A., *Jl* 82
 SHIDLOVSKAYA-OVCHINNIKOVA, Y. S., *Oc* 72
 SHINER, V. J., *My* 84
 SHIPE, E. L., *S* 76
 SHORT, F. R., *Oc* 66
 SHULL, I. F., *F* 62
 SILVEY, J. K., *S* 78
 SIMMONS, H. B., *Jl* 68
 SITTE, F., *Ja* 70
 SKADOVSKII, I. S. N., *Ap* 78
 SKODA, J., *Je* 92
 SMIRNOV, A. A., *N* 68
 SMITH, M. L., *My* 84
 SMITH, R. A., *Jl* 68
 SNYDER, W. M., *Oc* 92
 SOKOLOV, I. Y., *Oc* 88
 SONS, E., *Jl* 74
 SOULE, R. M., *Au* 86, *N* 66
 SOUTHGATE, B. A., *F* 68
 SPADARO, O., *Mr* 68
 SPELLS, K. E., *Jl* 68
 SPRINGS, J. D., *N* 78
 STACH, H., *Je* 66
 STANBRIDGE, H. H., *N* 66
 STANISAVLIEVICI, L., *Oc* 76
 STANLEY, D. R., *Jl* 66
 STEDMAN, R. L., *Jl* 62
 STEERE, A. C., *N* 68
 STEINIGER, F., *S* 77
 STEMEN, W. R., *My* 68

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(Continued from page 90 P&R)

STEVENS, J. C., *Oc* 94
STINI, J., *Au* 86
SUNNEN, T., *Ap* 74
SWAROOP, S., *S* 74
SWIFT, D. C., *Ja* 68, *Je* 81

TALSKY, J., *Oc* 88
TANAKA, M., *My* 86
TARZWELL, C. M., *My* 62
TAYLOR, E. W., *F* 62
TERRELL, P. W., *Oc* 92
THIEM, G., *Ja* 70
THOMAS, C. W., *Jl* 76
THOMAS, H. A., *F* 68
THOMAS, H. A., JR., *F* 66
TIEDEMAN, W. D., *Ap* 74
TINCHANT, X., *F* 70
TRACHUK, V. G., *Au* 90
TOEBES, C., *Jl* 68
TOLLER, W., *Je* 80
TOVBIN, M. V., *My* 88
TOWNSEND, C. B., *Mr* 64
TREBLER, H. A., *F* 70
TRUELSEN, C., *Jl* 74
TSUBOTA, H., *Je* 92
TSIVK, S. M., *Au* 90
TSYBA, N. P., *Oc* 84
TURTLE, R. B., *Jl* 68

UDLUFT, H., *Au* 78
UDSEN, M., *Ap* 66
UGEUX, E., *Au* 80
ULLERSTAM, A., *My* 68
UNGAR, J., *Jl* 82
UNZ, M., *Oc* 76
USPENSKAYA, V. I., *Ap* 78

VAN BENEDEN, G., *Oc* 76
VERESKOL, J., *Je* 92
VERMILLION, J. R., *Mr* 68
VERNHET, S., *N* 80
VIALARD-GOUDOU, A., *Ja* 68

VIEHL, K., *My* 74
VINS, V. Z., *Oc* 70
VIRE, *Mr* 72
VOLCKMAN, O. B., *Ap* 70, *Oc* 90

WALDBOTT, G. L., *Mr* 65, *Au* 74
WALLACE, G. M., *F* 62
WALMA, J., *Ap* 74
WALTERS, R. C. S., *Ja* 70
WATKINS, S. B., *Jl* 70
WEAVER, P. J., *Oc* 66
WEDGWOOD, P., *Jl* 86
WENDLAND, H., *Ap* 68
WENKE, B., *Ja* 68
WEST, P. N., *Oc* 70
WESTON, R. F., *My* 66
WHITFIELD, C. E., *My* 86
WELLS, E. A., *Oc* 92
WICKERT, K., *Jl* 86
WIEDERHOLD, W., *Jl* 82
WILKINSON, G. W., *Mr* 64
WILLIAMS, D. B., *N* 68
WILLIS, A. T., *S* 77
WILLSEY, W. B., *Je* 66
WILSER, O., *Jl* 74
WINSLOW, A. G., *Ja* 70
WOELFEL, W. C., *Oc* 66
WOOD, P. C., *S* 78
WOODWARD, R. L., *F* 66
WOOLLARD, L. D., *My* 80
WROUGHTON, D. M., *Je* 88
WURTZ, C. B., *F* 74

ZALL, D. M., *Oc* 70
ZAPIOR, B., *Je* 81
ZDANSKY, A. E., *N* 66
ZENIN, A. A., *Oc* 88
ZEE, C. H., *Jl* 74
ZIPKIN, I., *Au* 74
ZUCKERBIND, Z., *My* 84
ZYMNY, E., *My* 84

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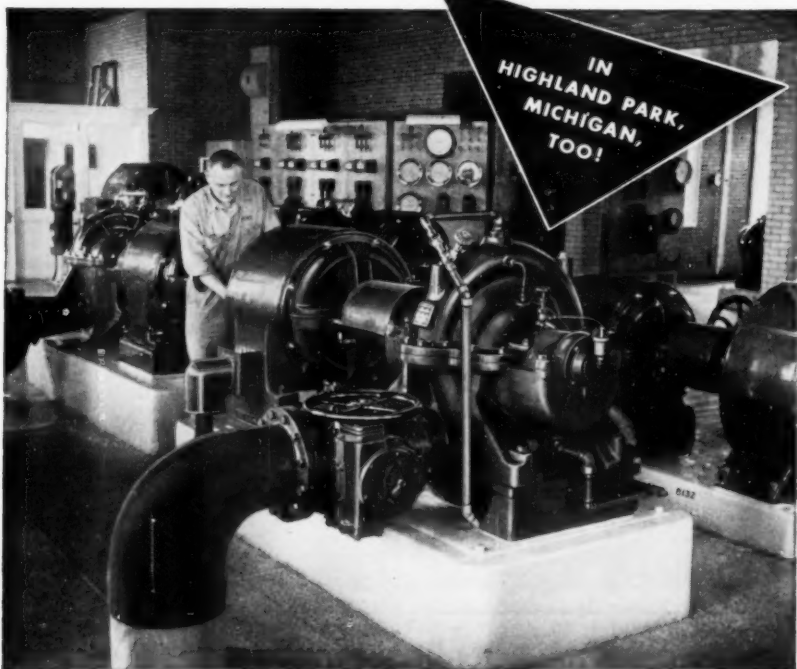
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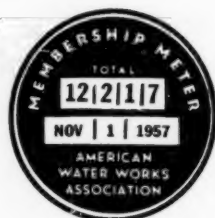


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Allmon, Larry Elmer, Utilities Supt., DX-Sunray Oil Co., Box 831, Duncan, Okla. (Oct. '57) *P*

Armstrong, George, Jr., Supt. of Water & Sewage Treatment, 223 Cherry St., St. Mary's, Ohio (Oct. '57) *P*

Becker, Jack, Sales Engr., The East Asiatic Co., 465 California St., Fremont, Calif. (Oct. '57) *D*

Bernhardt, George, Design Engr., Parsons, Brinckerhoff, Hail & MacDonald, 51 Broadway, New York 6, N. Y. (Oct. '57) *RPD*

Beyer, Arnold J., Chief Engr., Gary Steel Works, US Steel Corp., 1 N. Broadway, Gary, Ind. (Oct. '57) *PD*

Bloomington Water & Light Dept., M. L. Burgin, Director of Utilities, Box 674, Bloomington, Ill. (Munic. Sv. Sub. Oct. '57) *MRPD*

Bonner, Tom F., Supt. of Water & Sewer, Box 465, Fort Sumner, N.M. (Oct. '57) *MD*

Bottelsen, Walter Henry, Gen. Mgr., Cachuma Operation & Maint. Bld., 3301 Laurel Canyon Rd., Santa Barbara, Calif. (Oct. '57) *M*

Bremkamp, James K., Field Engr., Water Bond Issue Program, Munic. Bldg., Oklahoma City, Okla. (Oct. '57) *RD*

Bull, Thomas, West Coast Mgr., Cuno Eng. Corp., Box 271, Burlingame, Calif. (Oct. '57) *P*

Burgin, M. L.; see Bloomington (Ill.) Water & Light Dept.

Burzell, Linden R., Mgr., 402 Plymouth Dr., Vista, Calif. (Oct. '57) *M*

Butler, Jack D., Sales Engr., Lock Joint Pipe Co., Box 269, East Orange, N.J. (Oct. '57) *D*

Campbell, James Roland, Sales Engr., 4637 N. Hartford, Tulsa, Okla. (Oct. '57) *D*

Carhart, Kenneth J., Chief, Bureau of Examination & Licensing, State Dept. of Health, State House, Trenton 25, N.J. (Oct. '57) *MRPD*

Casey, Charles M.; see Nichols Hills (Okla.)

Chafetz, Arthur B., Cons. Engr., 838 S. Canyon, Carlsbad, N. Mex. (Oct. '57) *MRPD*

Chase, Thomas B., Foreman, Meter Repair Shop, 301 Bryant St., N.W., Washington, D. C. (Oct. '57) *D*

Cleland, Wilson M., Chief Operator, 310 S. 2nd St., St. Clair, Mich. (Oct. '57) *P*

Cohen, Seymour Phillip, Jr., Civ. Engr., Dept. of Water Resources, 1100 S. Grand Ave., Los Angeles, Calif. (Oct. '57) *R*

Colangelo, Anthony J., Sales Engr., Turbine Equipment Co., 63 Vesey St., New York 7, N.Y. (Oct. '57) *RD*

Cowles, Robert, Co-Partner, C&M Dredging, 4215 Cassopolis St., Elkhart, Ind. (Oct. '57) *PD*

Crawley, Evan, Mayor, City Hall, Greencastle, Ind. (Oct. '57)

Crom, James A., Engr., Stevens & Thompson, Box 508, Portland 7, Ore. (Oct. '57) *RPD*

Cross, C. L., Foreman, Alexandria Water Dept., Rte. 1, Boyce, La. (Oct. '57)

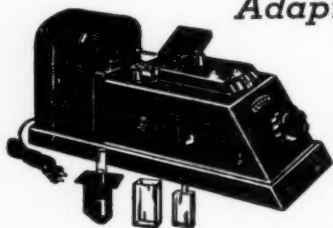
Curtis, William A., Office Engr., Boyle Eng., 3913 Ohio St., San Diego 4, Calif. (Oct. '57) *D*

Dagley, Leslie L., Vice-Mayor, 511 E. Valley Blvd., El Monte, Calif. (Oct. '57) *MP*

(Continued on page 96 P&R)

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(Continued from page 94 P&R)

Danielsen, Glen Earle, Director of Public Works, 7681—9th St., Buena Park, Calif. (Oct. '57) *M*

Davis, Herman Dempsey, Sales Engr., Link-Belt Co., 5938 Linsdale Ave., Detroit 4, Mich. (Oct. '57) *P*

Deal, Robert Louis, Supt., Power & Fuel Div., US Steel Corp., Gary Steel Works, Gary, Ind. (Oct. '57) *D*

Dellisanti, Adam J., Supervisor of Distr., Water Dept., 1106—1st St., Lorain, Ohio (Oct. '57) *D*

Dembitz, Adolph Edward, Chief Utilities Engr., Singmaster & Breyer, Inc., 420 Lexington Ave., New York 17, N.Y. (Oct. '57) *RD*

Dougherty, Donald F., Dist. Engr., Branch of Surface Water, Water Resources Div., US Geological Survey, Box 967, Trenton 6, N.J. (Oct. '57)

Drew, Howard R., Sr. Engr., Texas Electric Service Co., Box 970, Fort Worth, Tex. (Oct. '57) *R*

Dunlap, Lester Bennett, Engr., Brown & Caldwell, 66 Mint St., San Francisco 3, Calif. (Oct. '57) *R*

Dymock, Thomas, Project Engr., James F. MacLaren Assocs., 321 Bloor St., E., Toronto, Ont. (Oct. '57) *MRPD*

Fitch, Robert J., Sales Engr., Traverse City Iron Works, Traverse City, Mich. (Oct. '57) *PD*

Fox, Joseph M., Asst. Supervisor, Dept. of Public Works, Paterson, N.J. (Oct. '57) *D*

Friedgen, Robert D., Civ. Engr., Helix Irrigation Dist., 743 Katherine Place, El Cajon, Calif. (Oct. '55)

Galeano, Sergio F. Fortun, Civ. Engr., Ingenieria Vame S.A., Rancho Boyeros 774, Havana, Cuba (Oct. '57) *P*

Gibson, R. G., Sales Repr., Worthington-Gamon Meter Div., 2113 Ong St., Amarillo, Tex. (Oct. '57)

Gilchrist, W. A.; see Glendale (Ariz.)

Glendale, City of, W. A. Gilchrist, City Mgr., 38 N. 1st Ave., Glendale, Ariz. (Corp. M. Oct. '57) *MPD*

Green, Kenneth, Partner, Green Eng. Co., 1926 University Ave., Middleton, Wis. (Oct. '57)

Greenwich, Village of, Water Com., Harold C. Kipp, Water Supt., 79 Main St., Greenwich, N.Y. (Munic. Sv. Sub. Oct. '57)

Gronlund, Carl J., Mgr., County Waterworks Dist., 5082 N. Palm Ave., Fresno, Calif. (Oct. '57) *MD*

Grundy Center, City of, City Clerk, City Hall, Grundy Center, Iowa (Corp. M. Oct. '57) *MRPD*

Haberman, John M., Tech. Supervisor, Floyd G. Browne & Assocs., Marion, Ohio (Oct. '57) *MP*

Hamilton, James H., Resident Engr., Wiederman & Singleton, 760 W. Peachtree St., Atlanta, Ga. (Oct. '57) *PD*

Hamilton, Paul B., Water Works Supt., Water Works, Town Hall, Centerville, Ind. (Oct. '57) *MRPD*

Haneman, A., Jr., Supt., Water & Sewer Dept., Box 60, Abilene, Tex. (Oct. '57)

Haney, Ben J., Jr., Mech. Engr., Sewerage & Water Bd., New Orleans, La. (Oct. '57) *MD*

Hanger, Dave, Supt., Water Dept., Morocco, Ind. (Oct. '57)

Hansen, Ronald G., Asst. San. Engr., Water Quality Sec., State Dept. of Water Resources, 1100 S. Grand Ave., Los Angeles, Calif. (Oct. '57) *R*

Harris, R. F., Supt. of Distr., Water Dept., Box 449, Waco, Tex. (Oct. '57) *MD*

Harrold, Homer, Water Supt., Bd. of Trustees of Public Affairs, 579 Pittsburg St., Columbiana, Ohio (Oct. '57)

Hedrick, O. W.; see Knightdale (N.C.)

Henry, Marvin D., Asst. Water Supt., Water Dept., 1227 S. Riverside, Rialto, Calif. (Oct. '57) *MRPD*

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(Continued from page 96 P&R)

Herkless, Heber G., Works Mgr., Water & Light Plant, 19 N. Franklin St., Knightstown, Ind. (Oct. '57) *MD*

Hill, Harlan F., Supt., North Coast County Water Dist., Box 35, Sharp Park, Calif. (Oct. '57) *D*

Holden, Clarence R., Supt. of Plants, Water & Sewage Dept., Tulsa, Okla. (Oct. '57)

Holladay, Joe B., Asst. Water Supt., 118 N. Broadway, Weatherford, Okla. (Oct. '57) *PD*

Holtzelaw, Leon V., Asst. Supt., Water Dept., 3449 Central Ave., Port Arthur, Tex. (Oct. '57)

Hooper, Brian G., Dorr-Oliver-Long Ltd., 1819 Yonge St., Toronto 7, Ont. (Oct. '57)

Hori, Rijo, Civ. Engr., Bd. of Water Supply, Box 3410, Honolulu, T.H. (Oct. '57) *MR*

Hothan, Arwin W., San. Engr., Consoer, Townsend & Assoc., 360 E. Grand Ave., Chicago 11, Ill. (Oct. '57) *RPD*

Hovey, David H., Partner, Hovey-Cole & Assocs., 3734 Florida St., Baton Rouge, La. (Oct. '57) *PD*

Hutson, E. R., Supt., Water Dept., Box 974, Brownfield, Tex. (Oct. '57)

Hyre, Luther P., Branch Mgr., Chem. Dept., McKesson & Robbins, Inc., 216 Elm St., Des Moines, Iowa (Oct. '57) *P*

Imrie, George, Director of Public Works, Box 588, Reedley, Calif. (Oct. '57) *M*

Jackson, Robert F., Chief, Flood Control Sec., State Flood Control & Water Resources Com., 1330 W. Michigan St., Indianapolis 7, Ind. (Oct. '57) *R*

Jidy, Raul, Elec. Engr., Manzana de Gomez 314, Havana, Cuba (Oct. '57) *M*

Johnston, Floyd L., Supt. of Utilities, Box 253, Refugio, Tex. (Oct. '57)

Katz, Albert L., Jr., Sales Repr., Goodall Rubber Co., 2050 N. Hawthorne Ave., Melrose Park, Ill. (Oct. '57) *P*

Kelley, W. R., Water Plant Supt., Rte. 2, Foss, Okla. (Oct. '57)

Killam, Robert B., Temporary Town Engr., Yarmouth, N.S. (Oct. '57)

Klpp, Harold C.; see Greenwch (N.Y.) Water Com.

Klamser, Robert P., City Engr., Box 151, Raymond, Wash. (Oct. '57) *D*

Kleinodner, Robert E., City Engr., City Hall, Elyria, Ohio (Oct. '57) *D*

Knapp, Earle, Supt. of Public Works, 1820 Inverness, Pontiac, Mich. (Oct. '57) *RD*

Knightdale, Town of, O. W. Hedrick, Town Clerk, Knightdale, N.C. (Munic. Sv. Sub. Oct. '57) *MD*

Knisley, Marshall C., Supt. of Public Works, 7681—9th St., Buena Park, Calif. (Oct. '57) *D*

Kruse, Marvin Otto, Cons. Engr., Kruse Eng. Service, Spencer, Iowa (Oct. '57) *RPD*

La Junta Munic. Utilities, Tom Russell, City Mgr., 4th & Santa Fe, La Junta, Colo. (Corp. M. Apt. '57)

LeFevers, J. M., Acting Supt., Water Dept., Box 449, Waco, Tex. (Oct. '57) *M*

Lewis, Howard C., Mgr., Pump Dept., A. Y. McDonald Mfg. Co., 629 S.W. 9th, Des Moines, Iowa (Oct. '57) *RD*

Lingan, James B., Supt. of Mech. & Elec. Maint., Bureau of Water Supply, 3001 Druid Park Dr., Baltimore 15, Md. (Oct. '57)

Luckett, D. C., Foreman, Water Dept., 1806 Elliott, Alexandria, La. (Oct. '57)

Lufkin, City of, Harold Schmitzer, City Mgr., City Hall, Lufkin, Tex. (Munic. Sv. Sub. Oct. '57) *RD*

Mabin, William; see Scottsbluff (Neb.) Water Dept.

Macri, Nicholas D., Asst. Water Works Supt., Village Hall, Scarsdale, N.Y. (Oct. '57) *MPD*

Magnafichi, Rudolph F., Supt., Inland Lakes Sewer & Water Co., 661 Lake St., Grayslake, Ill. (Oct. '57) *MP*

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ELLIS & FORD MFG. CO.
2425 Goodrich Ave. Ferndale, Michigan
Phone Lincoln 7-3600

North East, Pennsylvania, selects Armco Pipe for economy, strength, high flow capacity



The 18- and 24-inch diameter pipeline crosses two deep gullies to bring water to North East, Pennsylvania.

The Borough of North East, Pennsylvania, needed more water to meet increasing requirements of residents and fruit processing plants. So they installed 9,500 feet of Armco Welded Steel Pipe to carry water from a new reservoir to the filter plant.

This water line required a strong, ductile pipe to withstand high pumping pressures and to adjust to an extremely hilly terrain. The pipeline crosses two gullies, 140 and 100 feet deep. Armco Pipe was selected because it provided the necessary strength at lowest cost. In addition, the smooth interior lining with its high "C" factor

provided four million gallons a day more than the design capacity.

Armco Pipe offers many advantages for any water line. Long lengths, up to 50 feet, mean fewer sections to haul and handle, fewer field joints. A wide range of diameters (from 6 to 36 inches) and wall thicknesses (from $\frac{3}{16}$ - to $\frac{1}{2}$ -inch) makes it easy for you to select exactly the size you need. Write for data applied to your requirements. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 4997 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.

ARMCO WELDED STEEL PIPE



(Continued from page 98 P&R)

- Maurice, Bertram C.**, Chief, Maint. Sec., Dalecarlia Filter Plant, 4900 MacArthur Blvd., N.W., Washington 16, D.C. (Oct. '57) *M*
- McCain, H. C.**, Sales Engr., Rockwell Mfg. Co., Box 2126, Houston, Tex. (Oct. '57) *D*
- McClure, Warren A.**, Gen. Mgr., North Coast County Water Dist., Box 35, Sharp Park, Calif. (Oct. '57) *MD*
- McClure, Warren A.**; see North Coast County (Calif.) Water Dist.
- McCoy, Lewis J.**, San. Eng. Graduate, Northwestern Univ., Evanston, Ill. (Jr. M. Oct. '57) *MP*
- McFadden, Robert Burton**, Asst. Water Supt., Water Dept., Bentonville, Ark. (Oct. '57) *MRPD*
- McPherson, Arthur G.**, Regional Sales Repr., Adams Pipe Repair Products, Box 36, Scottsburg, Ind. (Oct. '57) *M*
- Meharry, John F.**, Salesman, Hersey Mfg. Co., Box 31, Dedham, Mass. (Oct. '57) *D*
- Miller, Fred W.**, Asst. Supt., Water & Sewer System, Public Service Bd., El Paso, Tex. (Oct. '57)
- Milne, Frank**, Sales Repr., Hersey Mfg. Co., Box 643, Rochester 2, N.Y. (Oct. '57) *D*
- Moore, Detmer H.**, Supt. of Munic. Utilities, State Center, Iowa (Oct. '57)
- Moses, H. R.**; see Waxahachie (Tex.)
- Muench, Ray A., Jr.**, Admin. Asst., Public Works Com., Fayetteville, N.C. (Oct. '57) *M*
- Neumeyer, Charles F.**, Supervisor, Water Plant, L-O-F Glass Fibers Co., Waterville, Ohio (Oct. '57) *MP*
- Nichols Hills, Town of**, Charles M. Casey, Foreman, Water Dept., 6407 Avondale Dr., Oklahoma City 14, Okla. (Corp. M. Oct. '57) *M*
- Noecker, Max**, Prin. Engr., State Flood Control & Water Resources Com., 1330 W. Michigan, Indianapolis, Ind. (Oct. '57) *R*
- North Coast County Water Dist.**, Warren A. McClure, Gen. Mgr., Box 35, Sharp Park, Calif. (Corp. M. Oct. '57) *MRD*
- O'Shea, Daniel G.**, Project Engr., Weyerhaeuser Timber Co., Box 1645, Tacoma 1, Wash. (Oct. '57) *RPD*
- Patera, Edward L.**, Cons. Engr., 623 Royal Union Bldg., Des Moines, Iowa (Oct. '57)
- Pedersen, Carl, Jr.**, Sales Engr., Purser & London, Inc., Box 4156, Charlotte, N.C. (Oct. '57) *D*
- Permenter, Art**, Sales Engr., Standard Sand & Silica Co., Box 35, Davenport, Fla. (Oct. '57) *P*
- Peterson, Thoburn F.**, Asst. City Engr., Grand Forks, N.D. (Oct. '57) *D*
- Piehl, Robert A., Jr.**, Engr., DeLaval Steam Turbine Co., 1237 Texas National Bank Bldg., Houston 1, Tex. (Oct. '57) *RD*
- Quate, Boyd E.**, Vice-Pres., Weather Engrs., Inc., 6151 Freeport Blvd., Sacramento, Calif. (Oct. '57) *R*
- Reimers, Richard C.**, Contracting Engr., Pittsburgh-Des Moines Steel Co., Neville Island, Pittsburgh 9, Pa. (Oct. '57) *D*
- Rogers, Robert B.**, Sales Repr., Goodall Rubber Co., 2050 N. Hawthorne Ave., Melrose Park, Ill. (Oct. '57) *P*
- Ronsen, Gustav A.**, Plant Engr., Goodall Rubber Co., 2050 N. Hawthorne Ave., Melrose Park, Ill. (Oct. '57) *PD*
- Russell, Tom**; see La Junta (Colo.) Munic. Utilities
- St. Louis, City of**, Donald P. Ziemke, City Mgr., 108 W. Saginaw, St. Louis, Mich. (Munic. Sv. Sub. Oct. '57) *M*
- Schmitzer, Harold**; see Lufkin (Tex.)
- Scottsbluff, City of, Water Dept.**, William Mabin, Supt., Scottsbluff, Neb. (Corp. M. Oct. '57) *MRP*
- Waxahachie, City of**, H. R. Moses, Water Supt., Waxahachie, Tex. (Corp. M. Oct. '57)
- Ziemke, Donald P.**; see St. Louis (Mich.)

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Sodium Silicofluoride - 99%

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Meet AWWA specifications

White or tinted blue • Dry and free-flowing
 Minimum of storage space • Available in bags and drums
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growing with the gas and water industries

Founded in 1857, just one hundred years ago, Mueller Co. has grown steadily with the vital industries it serves.

In 1857: Only one company in the United States was furnishing gas to its twenty-one customers; water sold for a penny a bucket from wagons; Hieronymus Mueller worked in a one-room, one-man shop in Decatur.

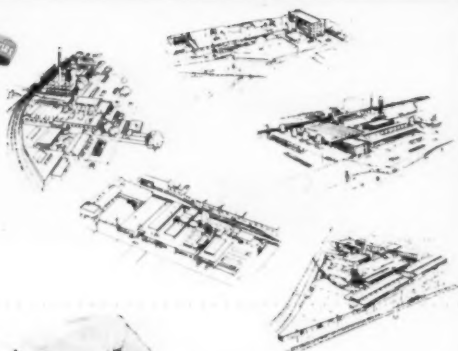
Today: Nearly 35 million Americans use gas for heating, cooking; more than 20,000 systems supply pure, fresh water to 130 million people; Mueller Co. is an organization with five modern factories, employing thousands of skilled craftsmen, manufacturing hundreds of quality products for water and gas distribution systems.

The water industry has made tremendous progress...the gas industry has had spectacular growth...Mueller Co. has kept pace with this march of progress!

1857



1957



engineering

New ideas—for new products and improvements on current products—are carefully analyzed and any with merit are passed on to trained project engineers for development. Approved designs are produced in the Mueller pattern shops by skilled craftsmen, and tested exhaustively—insuring performance in your equipment of tomorrow!



MUELLER ENGINEERS...

solving your problems of tomorrow—today!

As a major supplier of the equipment used by water works and gas companies, Mueller Co. research, engineering and manufacturing facilities are constantly striving to solve your problems of the future...and the answers are being found! New products, methods and equipment are being developed, current ones are being improved to further aid the growth of our vital water and gas industries.

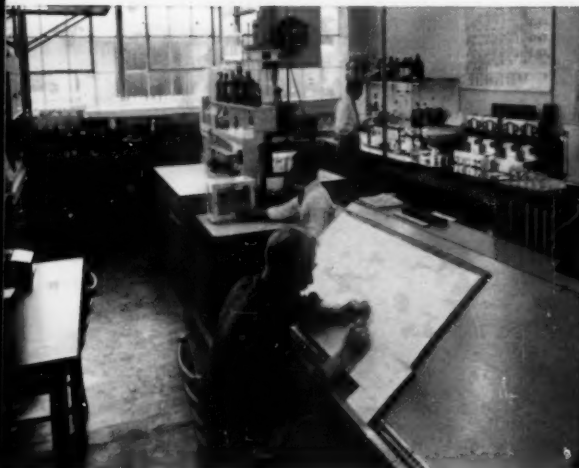
research

Metals, and other materials used in the manufacture of Mueller products, are subjected to rigorous tests and checks by laboratory technicians.

This constant search is for improvements to provide longer life and safer operating methods in the products you are using today and tomorrow.

manufacturing

Production methods are under study at all times to gain greater accuracy and quality. New machine tools and equipment are constantly being added to Mueller plant facilities to add more precision to Mueller products. Dependability—today and in the future—is assured!



COMING YOUR WAY...



1957 was a year of spectacular engineering accomplishment at Mueller Co. New engineering facilities were dedicated and from the boards of an expanded engineering staff came new and improved products. These products will soon be announced, and will be ready for you in '58!



"Watertown, U.S.A."...is a miniature city produced by the almost-lost art of diorama. Each tiny detail is reproduced in exact scale for its position in the scene and is proportioned to correspond to the overall "bird's eye" view. The perspective of each item is exaggerated to create an optical illusion which amplifies the depth. Through this means, a view of approximately 20 miles has been reproduced in less than 48 inches.



Unseen...unheard...UNDERGROUND!

Vital as the water and gas industries are, they receive little recognition for the vast facilities they must provide to serve their customers. Their products and their service systems lie underground—unseen and unheard.

Yet the story of these underground facilities is both dramatic and interesting to the general public. People have a more definite respect for the problems of the gas and water industries when they see the maze of equipment beneath their towns.

To help tell this story, Mueller Co. has prepared "Watertown, U.S.A."...a spectacular diorama that shows the work and facilities necessary to serve a community.

This is just one more way that Mueller Co. is looking to the future—the future of the vital industries which it serves!

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SHOCKING SITUATION

Solved by Rugged Steel Pipe

Water pipe lines suffer from many "shocking situations." Constant water hammer, traffic pounding, ground settling, extreme temperature changes, and abnormal shocks from earthquakes, floods, washouts, cave-ins and blastings take a terrific toll of rigid, brittle, types of pipe. But not flexible, ductile, high-strength steel pipe. Tough steel pipe is built to take it . . . engineered to resist the greatest shocks. Steel pipe gives you maximum protection against breaking plus the highest standard of serviceability.

So, when your plans demand a water pipe line that is steeled against shock, stress, and strain, you're smart to specify STEEL pipe.

"WHEREVER WATER FLOWS—STEEL PIPES IT BEST"

**STEEL PLATE FABRICATORS
ASSOCIATION**

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Section Meetings

Kentucky-Tennessee Section: The 29th annual meeting of the Kentucky-Tennessee Section was held Sep. 23-25 jointly with the Kentucky-Tennessee Industrial Wastes & Sewage Works Assn. The total registration was 317, which tied the record set in 1956. There was a large turnout of ladies—74 registered, compared with the previous high of about 50. Joint sessions of the two groups were held on Monday, Sep. 23, with separate sessions on Tuesday and Wednesday.

The address of welcome was given by

Henry Gerber, president of the Louisville Water Co., and Robert L. Lawrence, director of the Nashville Water Dept., gave the response. Excellent technical papers, panel discussions, and interesting movies were presented during the meeting. [A list of the papers and their authors appears on p. 1609 of this issue.]

The Louisville Water Co. was host at a dinner on Monday evening, and the Annual Banquet and Dance was held Tuesday evening. WSWMA held a cocktail party prior to the banquet. The follow-

(Continued on page 104 P&R)

N-SOL (ACTIVATED SILICA)

SOLVES THESE

WATER PROBLEMS . . . POOR QUALITY

N-Sol (activated silica sol) with your regular coagulant forms large, strong, rapid-settling floc and delivers clear, sparkling water. Evaluate results in your plant.

SAMPLES OF N SILICATE* AND DIRECTIONS FOR JAR TESTS ON REQUEST

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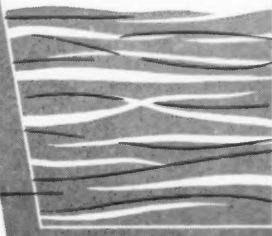
TRADEMARKS REG. U.S. PAT. OFF.

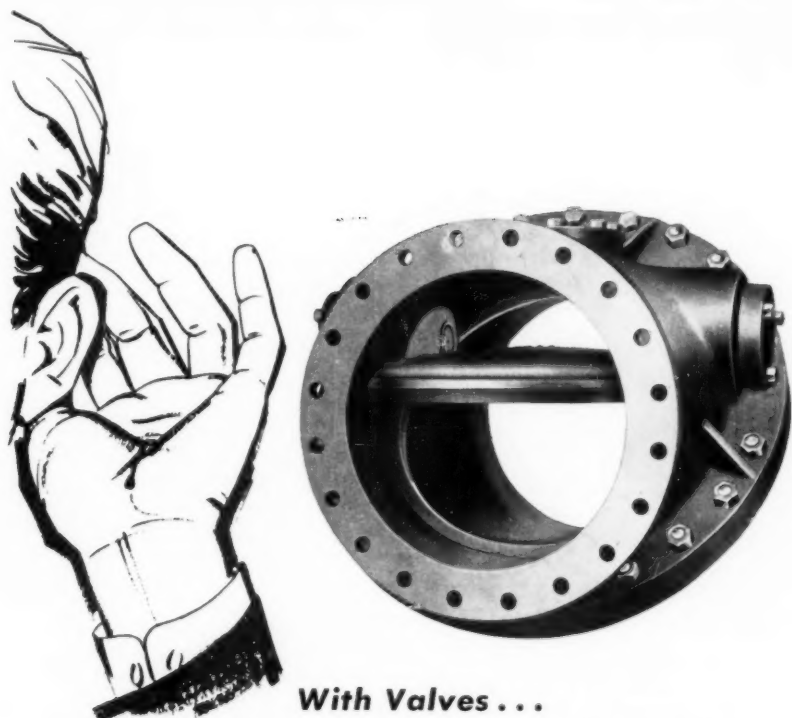
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N-SOL PROCESSES
PQ SOLUBLE SILICATES

- TURBIDITY
- COLOR
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- COLD WATER COAGULATION
- SHORT FILTER RUNS





With Valves . . .

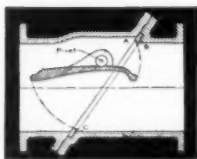
There's nothing like the silent treatment!

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Add it all up. With Chapman Tilting Disc Check Valves you get no flutter, no vibration, no slamming or jarring or scraping of disc and seat. You get fast, sure and *quiet* operation at all times.

This is the silent treatment for valves and what it means to you is a matter of dollars and cents. You have less headaches, less trouble, less maintenance for valves and system even under severe operating conditions.

This silent treatment is an exclusive with Chapman Tilting Disc Check Valves in iron and steel . . . has been for years. These quick and quiet valves handle fluids or gases under a wide range of pressures. You can order them for replacement or new systems. Why not, right now, check our Catalog, 30-A? If you don't have a copy readily on hand, write for it today.



Here's the Inside Story

When the flow is on, "airfoil disc," supported on pivot, floats on whatever flow there is. When the flow stops, disc drops quickly, quietly and firmly on special bevel seat. You'll note that there is sufficient space around disc to cut down flow resistance.

THE CHAPMAN VALVE MANUFACTURING CO.
INDIAN ORCHARD, MASSACHUSETTS



Chlorine valve inspection and cleaning at a Jones plant.

Here's why you get SAFE CHLORINE SERVICE from Jones

At John Wiley Jones Co., each cylinder valve must stand rigid inspection before it is passed for your use—the first step in a quality control system that assures you trouble-free operation. Testing and thorough valve cleaning before filling prevents leakage and contamination of your Chlorine.

Jones Chlorine meets tough government specifications . . . in 1-ton tanks or 16, 105 and 150-lb. cylinders.

Discover yourself why we supply more municipalities than all other packers combined. Seven Jones plants strategically located across the U.S. supply clean, pure Chlorine as you need it—in just a few hours.

Let us help solve your Chlorine problems. Call or write for information.

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JOHN WILEY JONES CO.

Section Meetings

(Continued from page 102 P&R)

ing awards were announced during the banquet: Fuller Award nomination to Charles H. Bagwell, Knoxville, Tenn.; Safety Award of Merit to Union City (Tenn.), Danville (Ky.), Corbin (Ky.), Hallsdale-Powell Utility Dist. (Tenn.), Whitehaven Utility Dist. (Tenn.), Hazard (Ky.), and Cumberland (Ky.); Safety Award of Honor to Memphis and Knoxville.

Officers selected to serve during the coming year are: chairman—Joe W. Lovell, Murfreesboro, Tenn.; vice-chairman—Henry M. Gerber, Louisville, Ky.; secretary-treasurer—J. Wiley Finney Jr., Lexington, Ky.; director—Elmer Smith, Owensboro, Ky.; trustee (Kentucky)—Jack D. Boxley, Hopkinsville; trustee (Tennessee)—Robert L. Lawrence Jr., Nashville; past-chairman—Robert A. Fischer, Covington, Ky.

J. WILEY FINNEY JR.
Secretary-Treasurer



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Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: \$1.50 per line (minimum \$5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

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HYDRAULIC ENGINEER: 14 years experience in pipelines, pumping, water resources. Desires to locate in Washington, D.C., as representative of water supply equipment manufacturer. Box 111, Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

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WATCH DOG

The meter used by thousands of municipalities in the U. S.



WATER METERS

"Watch Dog" models . . . made in standard capacities from 20 g.p.m. up: frost-proof and split case in household sizes. Disc, turbine, or compound type.

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE.



Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch

Dog Water Meters first choice of so many municipalities and private water companies in the United States.

WORTHINGTON-GAMON METER DIVISION

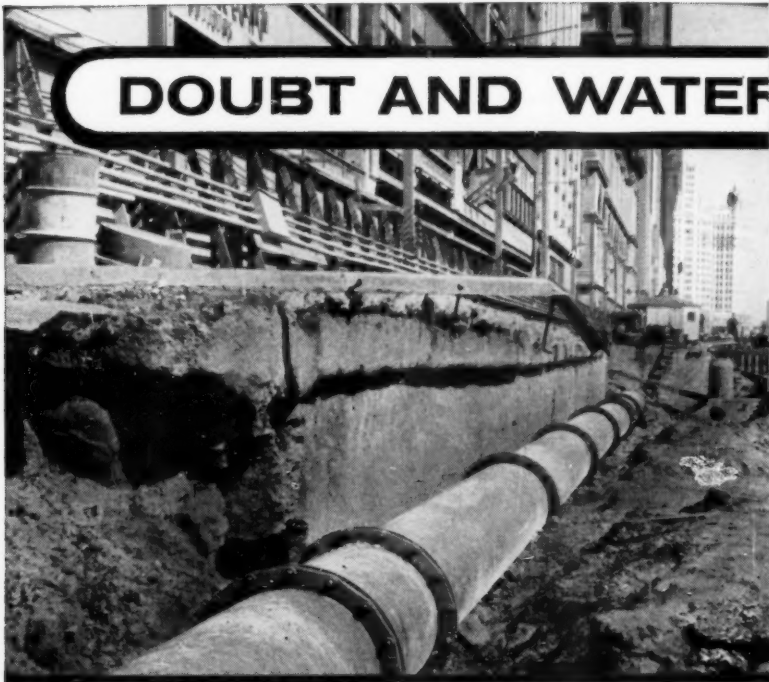
Worthington Corporation

296 SOUTH STREET, NEWARK 5, NEW JERSEY



OFFICES IN ALL PRINCIPAL CITIES

DOUBT AND WATER



Chicago, Ill. — Installing 24" Mechanical Joint cast iron pipe for water rerouted due to construction of underground garage beneath Michigan Ave.

When you choose pipe there should be no doubt . . . no single reservation as to its performance.

You can be sure when you specify cast iron pipe. Its long life, dependability, economy are *built in*—end result of five individual strength factors . . . all vital.

These factors . . . listed at right . . . have rolled up a service record unique in industry. 44 cities in the United States and Canada are still using cast iron water mains laid a century and more ago. Hundreds of others are nearing the century mark.

And today's *modernized* cast iron pipe, centrifugally cast, is even tougher, stronger, more durable.

What other pipe can offer you such assurance of performance?

CAST IRON PIPE

DON'T MIX!

**Dependability is based on strength.
Strength is based on these five factors**

- 1. CRUSHING STRENGTH*** . . . Standard 6" Class 150 cast iron pipe will withstand a crushing load, under standard tests, of 17,900 pounds per foot . . . important where heavy fill or unusually heavy traffic loads must be overcome.
- 2. BEAM STRENGTH*** . . . Settlement or disturbance of the soil by other utilities or resting on an obstruction places a heavy strain on pipe. 6" Class 150 pipe bears up under a load of 20,790 pounds and deflects 2.32 inches.
- 3. BURSTING STRENGTH*** . . . The average of many tests proves that standard 6" Class 150 cast iron pipe will not burst until subjected to internal pressure of 3000 pounds psi . . . ample to resist water hammer or unusual working pressures.
- 4. JOINT STRENGTH** . . . A full range of leak-proof, low cost, easy-to-assemble joints and fittings are available to meet all conditions.
- 5. CORROSION RESISTANCE** . . . Cast Iron Pipe resists corrosion effectively . . . vital factor in its demonstrated long life and dependability.

*Based on independent laboratory tests.

Tampa, Fla. — Installing large diameter trunk water mains from the pump station through the city and out to some of the fast growing residential sections.

CAST IRON

Cast Iron Pipe Research Association, Thos. F. Wolfe,
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During 1956 we built a large number of durable and efficient low cost water treating plants for the removal of iron, manganese, hardness and other undesirable impurities. These plants operate *automatically*, require very little space and are unusually inexpensive to operate and maintain.

Full Particulars on Request

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PLANS AHEAD FOR ITS FUTURE WATER NEEDS

Fast growing Atlanta, Ga., is one of many forward-looking cities in the U. S. A. which is making sure today that there will be no water shortage in the years ahead to retard city progress.

For the past five years, Atlanta has carried on a planned expansion of its water system under the direction of Mr. Paul Weir, general manager of the City's progressive Department of Water Works. Approximately 85 miles of cast iron distribution and feeder mains have been laid each year.

Present daily water requirements of Atlanta are 60 million gallons. By 1960, it is estimated they will be 68 million gallons, and by 1970, 90 million gallons.

When your community plans extension or improvement of its water system, be sure to specify —

Permanent CAST IRON PIPE

"America's No. 1 Tax Saver"

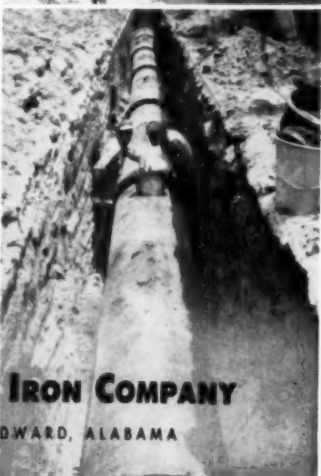
No other pipe has ever matched its proven record of longevity, dependability, low maintenance cost and long run economy. That's why it has long been known as "America's No. 1 Tax Saver."

Our Company does not manufacture Cast Iron Pipe but supplies many of the nation's leading foundries with quality pig iron from which quality pipe is made.



WOODWARD IRON COMPANY

WOODWARD, ALABAMA



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Sparling Meter Co.
Wallace & Tiernan Inc.

**Gages, Loss of Head, Pressure
of Vacuum, Rate of Flow,
Sand Expansion:**

Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)
Burgess-Manning Co., Penn In-
struments Div.
Foxboro Co.
Inflico Inc.
Jos. G. Pollard Co., Inc.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Gasholders:

Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:

James B. Clow & Sons
Johns-Manville Corp.

Gates, Shear and Sluice:

Armco Drainage & Metal Products,
Inc.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Mueller Co.
R. D. Wood Co.

Gears, Speed Reducing:

DeLaval Steam Turbine Co.
Worthington Corp.

Glass Standards—Colorimetric**Analysis Equipment:**

Klett Mfg. Co.
Wallace & Tiernan Inc.

Goose-necks (with or without**Corporation Stops):**

James B. Clow & Sons
Hays Mfg. Co.
Mueller Co.

Hydrants:

James B. Clow & Sons
Darling Valve & Mfg. Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
R. D. Wood Co.

Hydrogen Ion Equipment:

Wallace & Tiernan Inc.

Hypochlorite: see Calcium**Hypochlorite; Sodium Hy-
pochlorite****Ion Exchange Materials:**

Allis-Chalmers Mfg. Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Inflico Inc.
Permutit Co.
Roberts Filter Mfg. Co.

Iron, Pig:

Woodward Iron Co.

Iron Removal Plants:

American Well Works
Chain Belt Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Inflico Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Jointing Materials:

Hydraulic Development Corp.
Johns-Manville Corp.
Keasbey & Mattison Co.
Leadite Co., Inc.

Joints, Mechanical, Pipe:

American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Leak Detectors:

Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:

Dorr-Oliver Inc.
General Filter Co.
Inflico Inc.
Omega Machine Co. (Div., B-I-F
Industries, Inc.)

Permutit Co.

Wallace & Tiernan Inc.

Magnetic Dipping Needles:

W. S. Darley & Co.

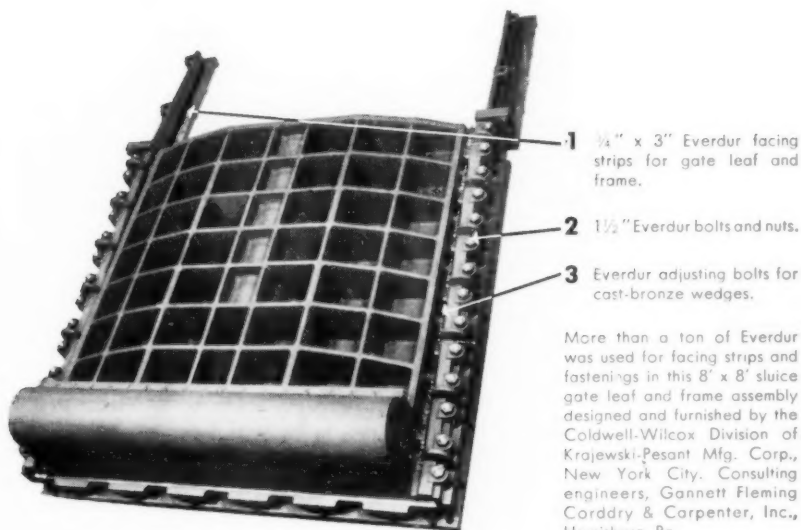
Meter Boxes:

Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:

Badger Meter Mfg. Co.
Dresser Mfg. Div.

2,300 pounds of Everdur used in new 8-ton cast-iron sluice gate



More than a ton of Everdur was used for facing strips and fastenings in this 8' x 8' sluice gate leaf and frame assembly designed and furnished by the Coldwell-Wilcox Division of Krajewski-Pesant Mfg. Corp., New York City. Consulting engineers, Gannett Fleming Corddry & Carpenter, Inc., Harrisburg, Pa.

This direct-pressure type sluice gate is one of two recently installed by Empresa de Energia Electrica at the Quebradona Dam in Columbia, South America, to regulate the flow of potable water to the city of Medellin.

The 100-foot head of water behind the dam exerts 450,000 pounds pressure on each 8 x 8-foot gate. Everdur* (copper-silicon alloy) was selected to seal against this load because of its high strength and corrosion resistance—plus ready work-

ability and weldability. Sewage treatment and water works equipment of Everdur has been in service without replacement for a quarter century and longer.

Write for Publication E-11, "Everdur Copper-Silicon Alloys for Sewage Treatment and Waterworks Equipment"—or for technical help in selecting the correct material for your job. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ont.

*Reg. U.S. Pat. Off. 57133

EVERDUR Anaconda's Family of Copper-Silicon Alloys
MADE BY THE AMERICAN BRASS COMPANY

STRONG • WORKABLE • WELDABLE • CORROSION-RESISTANT

Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Worthington-Gamon Meter Co.

Meter Reading and Record

Books:

Badger Meter Mfg. Co.
Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:

Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant,

Pumping Station,

Transmission Line:
Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)
Burgess-Manning Co., Penn In-
struments Div.
Foster Eng. Co.
Inflico Inc.
Simplex Valve & Meter Co.
Sparling Meter Co.

Meters, Industrial, Commer-

cial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)
Burgess-Manning Co., Penn In-
struments Div.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Sparling Meter Co.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meter Repair Parts

Meter Specialty Co.

Mixing Equipment:

Chain Belt Co.
General Filter Co.
Inflico Inc.
F. B. Leopold Co.

Paints:

Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.

Pipe, Asbestos-Cement:

Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:

American Brass Co.

Pipe, Cast Iron (and Fittings):

Alabama Pipe Co.
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:

American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Concrete:

American Concrete Pressure Pipe
Assn.

American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:

American Brass Co.

Pipe, Steel:

Armco Drainage & Metal Products,
Inc.
Bethlehem Steel Co.

Pipe Cleaning Services:

National Water Main Cleaning Co.

Pipe Cleaning Tools and

Equipment:

Flexible Inc.

Pipe Coatings and Linings:

American Cast Iron Pipe Co.
Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Reilly Tar & Chemical Corp.

Pipe Cutters:

James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
Reed Mfg. Co.
A. P. Smith Mfg. Co.

Pipe Jointing Materials; see

Jointing Materials

Pipe Locators:

W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pipe Vises:

Reed Mfg. Co.

Plugs, Removable:

James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potassium Permanganate:

Carus Chemical Co.

Pressure Regulators:

Allis-Chalmers Mfg. Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:

Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Layne & Bowler Pump Co.
Worthington Corp.

Pumps, Centrifugal:

Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.
Worthington Corp.

Pumps, Chemical Feed:

Inflico Inc.
Milton Roy Co.
Proportioners, Inc. (Div., B-I-F
Industries, Inc.)
Wallace & Tiernan Inc.

Pumps, Deep Well:

American Well Works
Layne & Bowler, Inc.
Layne & Bowler Pump Co.
Worthington Corp.

Pumps, Diaphragm:

Dorr-Oliver Inc.
W. S. Rockwell Co.
Wallace & Tiernan Inc.

Pumps, Hydrant:

W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:

Ross Valve Mfg. Co.

Pumps, Sewage:

Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

C. H. Wheeler Mfg. Co.
Worthington Corp.

Pumps, Sump:

DeLaval Steam Turbine Co.
Layne & Bowler Pump Co.
C. H. Wheeler Mfg. Co.
Worthington Corp.

Pumps, Turbine:

DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Layne & Bowler Pump Co.

Recorders, Gas Density, CO₂,

NH₃, SO₂, etc.:

Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:

Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)
Burgess-Manning Co., Penn In-
struments Div.

Inflico Inc.

Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Reservoirs, Steel:

Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.
Sparling Meter Co.

Sand Expansion Gages; see

Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping:

James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:

General Filter Co.
Graver Water Conditioning Co.
Permutit Co.

Sodium Chloride:

International Salt Co., Inc.

Sodium Fluoride

American Agricultural Chemical Co.

Sodium Hexametaphosphate:

Calgon Co.

Sodium Hypochlorite:

John Wiley Jones Co.
Wallace & Tiernan Inc.

Sodium Silicate:

Philadelphia Quartz Co.

Sodium Silicofluoride

American Agricultural Chemical Co.
Tennessee Corp.

Softeners:

Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Inflico Inc.
Permutit Co.

Roberts Filter Mfg. Co.

Walker Process Equipment, Inc.

Softening Chemicals and Com-

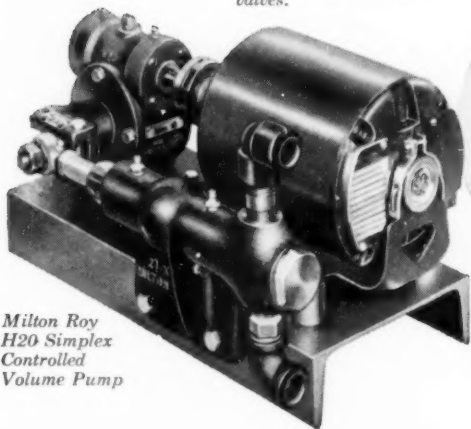
pounds:

Calgon Co.
Cochrane Corp.
General Filter Co.
Inflico Inc.
International Salt Co., Inc.
Permutit Co.
Tennessee Corp.

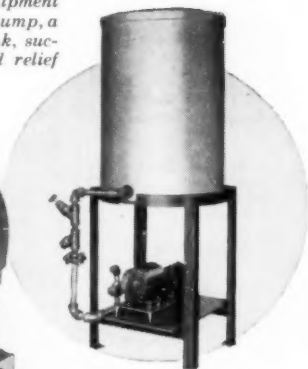
Standpipes, Steel:

Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Tank & Mfg. Co.

Typical packaged system for water treating ready for shipment includes an H20 simplex pump, a 50-gallon polyethylene tank, suction piping, close-off and relief valves.



*Milton Roy
H20 Simplex
Controlled
Volume Pump*



Controlled Volume Pumps meter chemical solutions accurately

You can depend on Milton Roy H20® Controlled Volume Pumps to meter your boiler-water treatment chemicals accurately, in addition to other mildly corrosive and non-corrosive liquids.

High metering accuracy, long service life, minimum maintenance, availability from stock, and low cost are all advantages of H20 pumps. They embody quality design features usually found only in higher priced pumps, including: self-aligning bearings . . . self-adjusting packing . . . double ball checks on

suction and discharge . . . cartridge-type, easily replaceable valves . . . standard continuous flushing connections.

For your water treating jobs, Milton Roy Controlled Volume Pumps can provide the logical, economical answer to chemical metering as well as accurate flow control. Write for Bulletin 557.

Milton Roy Company, 1300 East Mermaid Lane, Philadelphia 18, Pa.
Engineering Representatives throughout the world.



CONTROLLED VOLUME PUMPS • QUANTICHEM ANALYZERS
CHEMICAL FEED SYSTEMS • ANDERS AIR AND GAS DRYERS

Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:

Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:

Hays Mfg. Co.
Mueller Co.

Storage Tanks: see Tanks

Strainers, Suction:

James B. Clow & Sons
M. Greenberg's Sons
R. D. Wood Co.

Surface Wash Equipment:

Cochrane Corp.
Permutit Co.

Swimming Pool Sterilization:

Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)
Omega Machine Co. (Div., B-I-F
Industries, Inc.)
Proportioneers, Inc. (Div., B-I-F
Industries, Inc.)

Tanks, Steel:

Wallace & Tiernan Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:

Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:

Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:

Builders-Providence, Inc. (Div.,
B-I-F Industries, Inc.)
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.

Inflico Inc.

Permutit Co.

Proportioneers, Inc. (Div., B-I-F
Industries, Inc.)

Wallace & Tiernan Inc.

**Turbidimetric Apparatus (For
Turbidity and Sulfate De-
terminations):**

Wallace & Tiernan Inc.

Turbines, Steam:

Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:

Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:

James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:

Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:

Golden-Anderson Valve Specialty Co.

W. S. Rockwell Co.

Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap,

Foot, Hose, Mud and Plug:

Builders-Providence, Inc. (Div.,

B-I-F Industries, Inc.)

Chapman Valve Mfg. Co.

James B. Clow & Sons

DeZurik Corp.

M. Greenberg's Sons

Kennedy Valve Mfg. Co.

M & H Valve & Fittings Co.

Henry Pratt Co.

Rensselaer Valve Co.

W. S. Rockwell Co.

S. Morgan Smith Co.

R. D. Wood Co.

Valves, Detector Check:

Hersey Mfg. Co.

Valves, Electrically Operated:

Builders-Providence, Inc. (Div.,

B-I-F Industries, Inc.)

Chapman Valve Mfg. Co.

James B. Clow & Sons

Crane Co.

Darling Valve & Mfg. Co.

DeZurik Corp.

Golden-Anderson Valve Specialty Co.

Kennedy Valve Mfg. Co.

M & H Valve & Fittings Co.

Mueller Co.

Henry Pratt Co.

Rensselaer Valve Co.

W. S. Rockwell Co.

A. P. Smith Mfg. Co.

S. Morgan Smith Co.

Valves, Float:

James B. Clow & Sons

Golden-Anderson Valve Specialty Co.

Henry Pratt Co.

W. S. Rockwell Co.

Ross Valve Mfg. Co., Inc.

Valves, Gate:

Chapman Valve Mfg. Co.

James B. Clow & Sons

Crane Co.

Darling Valve & Mfg. Co.

DeZurik Corp.

Dresser Mfg. Div.

Kennedy Valve Mfg. Co.

Ludlow Valve Mfg. Co., Inc.

M & H Valve & Fittings Co.

Mueller Co.

Rensselaer Valve Co.

W. S. Rockwell Co.

A. P. Smith Mfg. Co.

R. D. Wood Co.

Valves, Hydraulically Oper-

ated:

Builders-Providence, Inc. (Div.,

B-I-F Industries, Inc.)

Chapman Valve Mfg. Co.

James B. Clow & Sons

Crane Co.

Darling Valve & Mfg. Co.

DeZurik Corp.

Golden-Anderson Valve Specialty Co.

Kennedy Valve Mfg. Co.

F. B. Leopold Co.

M & H Valve & Fittings Co.

Mueller Co.

Henry Pratt Co.

Rensselaer Valve Co.

W. S. Rockwell Co.

A. P. Smith Mfg. Co.

S. Morgan Smith Co.

R. D. Wood Co.

Valves, Large Diameter:

Chapman Valve Mfg. Co.

James B. Clow & Sons

Crane Co.

Darling Valve & Mfg. Co.

Golden-Anderson Valve Specialty Co.

Kennedy Valve Mfg. Co.

Ludlow Valve Mfg. Co., Inc.

M & H Valve & Fittings Co.

Mueller Co.

Henry Pratt Co.

Rensselaer Valve Co.

W. S. Rockwell Co.

A. P. Smith Mfg. Co.

S. Morgan Smith Co.

R. D. Wood Co.

Valves, Regulating:

DeZurik Corp.

Foster Eng. Co.

Golden-Anderson Valve Specialty Co.

Mueller Co.

Henry Pratt Co.

W. S. Rockwell Co.

Ross Valve Mfg. Co.

S. Morgan Smith Co.

Valves, Swing Check:

Chapman Valve Mfg. Co.

James B. Clow & Sons

Crane Co.

Darling Valve & Mfg. Co.

Golden-Anderson Valve Specialty Co.

M. Greenberg's Sons

M & H Valve & Fittings Co.

Mueller Co.

Rensselaer Valve Co.

W. S. Rockwell Co.

A. P. Smith Mfg. Co.

R. D. Wood Co.

Venturi Tubes:

Builders-Providence, Inc. (Div.,

B-I-F Industries, Inc.)

Burgess-Manning Co., Penn In-

struments Div.

Inflico Inc.

Simplex Valve & Meter Co.

Waterproofing:

Barrett Div.

Inertol Co., Inc.

Koppers Co., Inc.

Water Softening Plants: see

Softeners

Water Supply Contractors:

Layne & Bowler, Inc.

Water Testing Apparatus:

Wallace & Tiernan Inc.

Water Treatment Plants:

American Well Works

Chain Belt Co.

Chicago Bridge & Iron Co.

Cochrane Corp.

Dorr-Oliver Inc.

Etablissements Degremont

General Filter Co.

Graver Water Conditioning Co.

Hammond Iron Works

Hungerford & Terry, Inc.

Inflico Inc.

Permutit Co.

Pittsburgh-Des Moines Steel Co.

Roberts Filter Mfg. Co.

Walker Process Equipment, Inc.

Wallace & Tiernan Inc.

Well Drilling Contractors:

Layne & Bowler, Inc.

Wrenches, Ratchet:

Dresser Mfg. Div.

Zeoilite: see Ion Exchange

Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.



**HOW TO
SAVE MONEY
FROM
THE TRENCH
TO THE
PUMP**

**Specify
Concrete
Pressure
Pipe!**

There's no spiralling pumping cost when you specify low-cost, long-lasting Concrete Pressure Pipe for your city. Because of its extreme resistance to corrosion and tuberculation, the high initial carrying capacity of Concrete Pressure Pipe remains unimpaired throughout its unusually long lifespan. Your city gets impressive dollar savings because this pipe's inner surface stays smooth indefinitely.

To save money for your city—from the trench to the pump—specify Concrete Pressure Pipe and get these "4 big savings" built into every piece of durable, trouble-free Concrete Pressure Pipe.

- 1.** *You save on first costs*—The variety of designs available in Concrete Pressure Pipe makes it possible to choose the most economical design which will serve with maximum efficiency under the specified operating conditions required of the line.
- 2.** *You save on installation costs*—With Rubber Gasket Joints, there's no caulking, bolting or welding needed. You can have minimum width trenches and immediate backfilling.
- 3.** *You save on maintenance costs*—Concrete Pressure Pipe has an experience record of almost complete freedom from corrosion and tuberculation. Elastic design virtually eliminates possibility of bursting—even under conditions of extreme surge and water hammer.
- 4.** *You save on operating costs*—Freedom from tuberculation insures a high sustained carrying capacity. Smooth flow keeps pumping costs low.

IN THE MAIN—THE TREND IS TO CONCRETE!

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION

228 North LaSalle Street

Chicago 1, Illinois

Member companies manufacture Concrete Pressure Pipe in accordance with nationally recognized specifications.

Rockwell Dual Unit Compound Meter Assemblies



EASIEST To Handle, Install, Service

Big, bulky 8 in. compound meters are always a trial to install, even more of a problem to service. Now, with Rockwell—two meter single register compound manifolds you can save time and money. The complete assembly weighs approximately 100 lbs. less than a single big meter. Two men can handle it with ease. Maintenance of this Rockwell unit is a cinch. Either meter can be used to record off-peak loads while a new or repaired meter is being installed. And remember, Rockwell Dual Unit meter assemblies are razor sharp

in the measurement department. They record *all the flows* with far greater accuracy than a single 8" compound. And they cost less. Write for latest bulletin.

ROCKWELL MANUFACTURING COMPANY

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Charlotte Chicago Dallas Denver
Houston Los Angeles Midland, Tex.
New Orleans New York N. Kansas City
Philadelphia Pittsburgh San Francisco
Seattle Shreveport Tulsa In Canada:
Rockwell Manufacturing Company of
Canada, Ltd., Toronto, Ontario



ROCKWELL WATER METERS

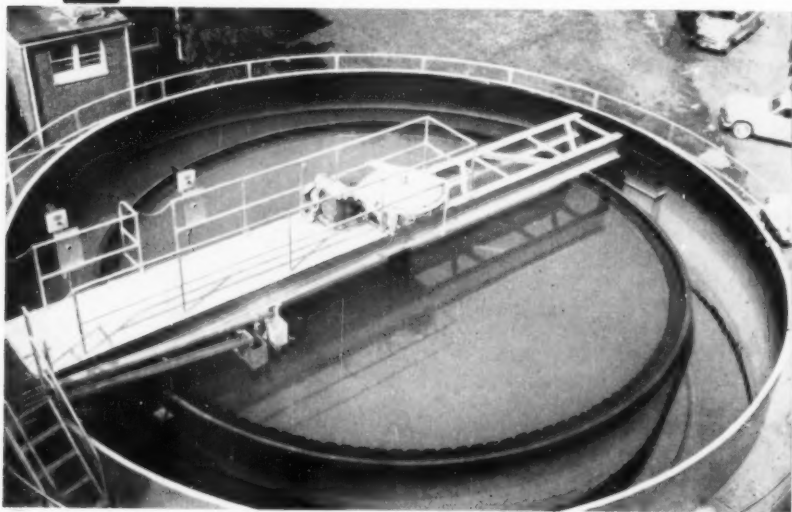
A Size and Type For Every Kind of Service





The solution to this problem is always the same . . . but
Water Treatment Problems are different

No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job . . . and not vice versa.



Fountain City TENNESSEE

PeriFilter System employs split filter for continuous operation

Producing 1.0 MGD of finished water from limestone springs at Fountain City, this Dorrco PeriFilter System consists of a single 30' dia. Hydro-Treator surrounded by an annular rapid sand filter. To maintain continuous operation, the filter is split by a partition plate and backwashed one half at a time. During backwashing, Hydro-Treator effluent overflows into the inner launder and is distributed to

the opposite half of the filter. The results at Fountain City have been uniformly excellent with an average turbidity in the filtered water of less than 0.3 ppm.

For more information on the complete line of D-O equipment for the water works industry write for a copy of Bulletin No. 9041. Dorr-Oliver Incorporated, Stamford, Connecticut.

Close up of PeriFilter System taken while backwashing right side of filter. Left side of filter remains in operation.

Consulting Engineers: Fulk, Powell and Nandan, Birmingham, Alabama.

Hydro-Treator, Peri-Filter, T.M. Reg. U. S. Pat. Off.

Every day over 8½ billion gallons of water are treated by Dorr-Oliver equipment.



DORR-OLIVER

INCORPORATED
 WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
 STAMFORD • CONNECTICUT • U.S.A.

LEADITE

Trade Mark Registered U. S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains **MUST BE GOOD**,—**MUST BE DEPENDABLE**,—and that is just why so many Engineers, Water Works Men and Contractors aim to **PLAY ABSOLUTELY SAFE**, by specifying and using **LEADITE**.

Time has proven that **LEADITE** not only makes a tight durable joint,—but that it improves with age.

*The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%*



THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking

